Pharmacy5in5: Evaluating a computer-based education platform to improve pharmacists' knowledge and behaviour

by

Rand Nidal Yousef Hussein

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Pharmacy

Waterloo, Ontario, Canada, 2022

Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External member Examiner	Parisa Aslani Professor School of Pharmacy The University of Sydney
Supervisor	Kelly Grindrod Associate Professor School of Pharmacy University of Waterloo
Internal Member	Tejal Patel Associate Clinical Professor School of Pharmacy University of Waterloo
Internal Member	Sherilyn Houle Assistant Professor School of Pharmacy University of Waterloo
Internal-external Member	Kelly Skinner Associate Professor School of Public Health Sciences, Faculty of Health University of Waterloo

Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Rand Hussein was the sole author for Chapters 1 and 5 which were written under the supervision of Dr. Kelly Grindrod and were not written for publication.
This thesis consists in part of three manuscripts written for publication. Exceptions to sole authorship of material are as follows:

Research presented in Chapter 2:

This research was conducted at the University of Waterloo by Rand Hussein under the supervision of Dr. Kelly Grindrod. Dr. Kelly Grindrod and Rand Hussein contributed to study design. Esther Lin and Rand Hussein completed the abstract and full text screening. Esther Lin and Rand Hussein completed the data analysis and interpretation of results with assistance from Dr. Kelly Grindrod. Rand Hussein wrote the manuscript draft. Dr. Kelly Grindrod and Esther Lin contributed to the writing of the manuscript. All authors reviewed various drafts of the manuscript and approved the final manuscript.

Citation
Chapter 2: Hussein R, Lin EC, Grindrod K**.** Effects of computer-based education on health professionals' knowledge, skills, and behavior: A scoping review**.** Journal of the American Pharmacists Association**.** Volume 61, Issue 3, 2021, Pages e44-e68, ISSN 1544-3191

https://doi.org/10.1016/j.japh.2021.01.036.

Research presented in Chapter 3:

This research was conducted at the University of Waterloo by Rand Hussein under the supervision of Dr. Kelly Grindrod. Dr. Kelly Grindrod and Rand Hussein contributed to the design of the study. Rand Hussein developed the survey and the interview guide with assistance from Dr. Kelly Grindrod. Rand Hussein also conducted the telephone interviews and analyzed the survey data. Colin Whaley, Esther Lin and Rand Hussein completed the

coding and the analysis of the interview data and interpretation of results with assistance from Dr. Kelly Grindrod. Rand Hussein wrote the manuscript draft. Dr. Kelly Grindrod, Colin Whaley, and Esther Lin contributed to the writing of the manuscript. All authors reviewed various drafts of the manuscript and approved the final manuscript.

Citation

Chapter 3: Hussein R, Whaley CR, Lin EC, Grindrod K. Identifying barriers, facilitators and behaviour change techniques to the adoption of the full scope of pharmacy practice among pharmacy professionals: Using the Theoretical Domains Framework. Research in Social and Administrative Pharmacy. Volume 17, Issue 8, August 2021, Pages 1396-1406 https://doi.org/10.1016/j.sapharm.2020.10.003

Research presented in Chapter 4:

This research was conducted at the University of Waterloo by Rand Hussein under the supervision of Dr. Kelly Grindrod. Dr. Kelly Grindrod and Rand Hussein contributed to the study design. Rand Hussein developed the quizzes for the Anticholinergic Toxicity module with assistance from Dr. Kelly Grindrod and Rosemary Killeen. Julia Bareham, Dr.Tejal Patel, Rosemary Killeen and Dr. Kelly Grindrod contributed to the validation of the module. Rand Hussein developed the knowledge test with assistance from Dr. Kelly Grindrod. Julia Bareham, Dr.Tejal Patel, Rosemary Killeen and Dr. Kelly Grindrod contributed to the validation of the knowledge test. Rand Hussein completed the recruitment and follow-up with the study participants. Rand Hussein completed the data analysis and interpretation of results with assistance from Dr. Kelly Grindrod and Zhoushanyue He. Rand Hussein wrote the manuscript draft. Dr. Kelly Grindrod, Julia Bareham, Dr.Tejal Patel, Rosemary Killeen and Zhoushanyue He contributed to the writing of the manuscript. All authors reviewed various drafts of the manuscript and approved the final manuscript.

Citation

Chapter 4: Hussein R, He Z, Bareham J, Patel T, Killeen R, Grindrod K. Evaluating the Effectiveness of the Computer-Based Education Platform, Pharmacy5in5, on Pharmacists' Knowledge of Anticholinergic Toxicity Using a Randomized Controlled Trial. Pharmacy. 2022; 10(1):8. https://doi.org/10.3390/pharmacy10010008

As lead author of the manuscripts for Chapters 2, 3 and 4, I was responsible for contributing to study design, guiding and completing data collection and analysis, drafting and submitting manuscripts. The co-authors listed with each chapter provided guidance and feedback on draft manuscripts.

Abstract

Background The pharmacist's role continues to evolve and expand from the traditional role of dispensing to a more patient-centered model of care. However, many pharmacists still fall short in terms of their provision of full scope pharmacy services. A new behaviour change intervention is needed to help pharmacists adopt these pharmacy services. One such intervention is computer-based education. There is limited research exploring the effect of computer-based education on pharmacist knowledge, skills and behaviours. There is also a gap in literature on how to refine and design a computer-based educational platform targeting pharmacy professionals.

Objectives The overall goal of this thesis is to provide step-wise guidance on how to design theory-based interventions and to provide outcome information on the effect of an educational platform on improving pharmacists' knowledge.

Methods This thesis is comprised of three studies. The first study was a scoping review that explored the current literature on how computer-based education affects healthcare professionals' knowledge, skills and behaviour. The second study used a mixed methods approach which combined a self-reported survey with semi-structured interviews to explore barriers, facilitators and corresponding behaviour change techniques that are applicable to computer-based education. Based on these findings, the third study assessed the effect of one example of computer-based education on pharmacists' knowledge using a randomized controlled trial.

Results The scoping review showed that studies assessing the effect of computer-based education were mostly focused on user satisfaction, knowledge gain and self-reported

behaviour. Moreover, few studies reported using a theoretical framework for the development of or to guide the selection of design features. Using the theoretical domains framework, a wide range of barriers and facilitators were identified for full scope services. Moreover, a total of 18 behaviour change techniques were identified which can be incorporated into computer-based education. The randomized controlled trial showed that computer-based education can significantly improve knowledge and is at least as effective as printed education material.

Conclusion With the rapid transition to computer-based education due to the COVID-19 pandemic, a better understanding of computer-based education is critical. This thesis demonstrates the effectiveness of computer-based education in educating pharmacists, as well as its promising potential as a behaviour change intervention. More rigorous evaluation is needed to assess all possible learning outcomes including behaviour and practice change.

Acknowledgements

I wish to thank all the incredible people who supported me throughout my PhD. First, I would like to thank my supervisor Dr. Kelly Grindrod for your guidance professionally and personally through this journey. I am forever grateful to you for giving me the chance to pursue my dream of getting a PhD in pharmacy. Thank you for showing me a great example of what a mentor, researcher, and pharmacist should be.

I would also like to thank my committee members for their encouragement and guidance, Dr. Tejal Patel, Dr. Sherilyn Houle and Dr. Kelly Skinner. Thank you for sharing your expertise and knowledge. Your feedback and support have been invaluable.

To Rosemary Killeen, thank you for your countless hours of reading and editing to improve this work.

A special thanks to Melinda Recchia for being always available to address my endless questions and concerns.

To Ai-Leng Foong and Ashely Cid, thank you for reviewing and polishing this work.

To all Pharmacy5in5 users who participated in this research, thank you for making this research possible.

This work was supported by the Ontario Graduate Scholarship (OGS)

Dedication

To mom and dad,
Thank you for your unconditional love and support,
I couldn't have done this without you

To my husband,
Thank you for being my rock

To my baby Sarah,
Thank you for joining me through every thought of this journey

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AB	Alberta
ASD	Aging semantic differential
BCC	Basal cell carcinoma
BCT taxonomy v1	Behaviour Change Techniques Taxonomy Version 1
BCTs	Behaviour change techniques
BCW	Behaviour change wheel
CBE	Computer-based education
CD-ROMs	Compact disc read-only memory
CE	Continuing education
CEU	Continuing education unit
CI	Confidence interval
CINAHL	The Cumulative Index to Nursing and Allied Health Literature
CKD	Chronic kidney disease
CME	Continuing medical education
COM-B	Capability, opportunity, motivation, and behaviour model
CONSORT-EHEALTH	Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth
CPD	Continuing professional development
CPG	Clinical practice guideline
CT	Computer-tailored
CTAS	Canadian Triage and Acuity Scale
CtC-method	Commitment-to-change method
DCTEP	Dementia Care Training and Education Program
DKAS	Dementia Knowledge Assessment Scale
DOS	Delirium observation screening
e-PBL	Electronic problem-based learning
EBM	Evidence-based medicine
ED	Emergency department
EOVs	Educational outreach visits
ERIC	Education Resources Information Center
FEP	Frail Elderly Project
GETUP	Global Educational Toxicology Uniting Project
GME	Graduate medical education

GP	General practitioner
GPACS-D	General Practitioner Attitudes and Confidence Scale for Dementia
GPN	General practice nurse
HCPs	Healthcare professionals
HPs	Health professionals
i-CVI	Item-content validly index
ICM	I-Change Model
ICTs	Information and communication technologies
IMG	International medical graduate
INFORMED	Internet curriculum for melanoma early detection
IPA	International Pharmaceutical Abstracts
IQR	Interquartile range
ISE	Interactive spaced education
LDS	Learner demographic survey
LMS	Learning management system
LSAe-L	Learner Satisfaction with Asynchronous e-Learning
MB	Manitoba
MCQs	Multiple choice questions
N/A	Not available
NP	Nurse practitioner
NS	Nova Scotia
OLSI	Online learner support instrument
ON	Ontario
OP	Occupational physician
OR	Odds ratio
OSCE	Objective structured clinical examination
PBL	Problem-based learning
PC	Palliative care
PCP	Primary care provider
PN	Practice nurse
RCT	Randomized controlled trial
RN	Registered nurse
RT	Respiratory therapist
SCC	Squamous cell carcinoma
SD	Standard deviation
SHC	Sexual health care

SIA	Staghorn calculi, infertility, and antibiotic use
STI	Sexually transmitted infection
SUS	Systems usability scale
T/F	True/false
TDF	Theoretical domains framework
TPB	Theory of Planned Behaviour
WeBREATHe	Web-Based respiratory education about tobacco and health

Chapter 1

Introduction and Literature Summary

1.1 Changing scope of practice

The pharmacy profession is constantly changing with roles expanding for pharmacists in Canada. As their focus shifts to a patient-centered approach, pharmacists are now providing a wide range of services that can improve patient outcomes. These services vary by province and include medication reviews, independent prescribing, adapting prescriptions, chronic disease management, and vaccination.[1,2] Evidence has demonstrated the positive effect of pharmacy services on improving clinical outcomes and reducing healthcare costs.[2-6] However, despite the supporting legislation, the implementation of these services is suboptimal.[1,7,8] For example, a recent study in Ontario reported that medication review services by pharmacists reached only 1 in 9 eligible patients.[9] Similarly, another study conducted in Ontario examined medication review services among patients with diabetes and found that 50% of eligible diabetic patients received a medication review, but only 2.7% received a follow-up assessment.[10] Furthermore, a study in British Columbia highlighted the suboptimal implementation of medication management services with no change in the number of potentially inappropriate medications prescribed after assessment.[11] Therefore, it appears that pharmacists would benefit from educational activities that support the behaviour change required to improve the uptake of pharmacy services, and enable desired changes in practice to improve patient outcomes.

1.2 Interventions to optimize pharmacists' behaviour

Many interventions have been designed to target the behaviour of healthcare professionals (HCPs) including pharmacists, such as educational meetings,[12] reminders,[13] and educational outreach visits.[14]However, evidence has shown that these interventions can improve HCPs knowledge, but have only a small effect on HCPs behaviour and patient outcomes.[14-16] For example, a Cochrane review by O'Brien et al.[14] focusing on educational outreach visits (EOVs), such as academic detailing, concluded that EOVs improved physicians' prescribing behaviour by 5%. Another Cochrane review of audit and feedback concluded that this intervention slightly improved HCPs' compliance with the desired practice by 4%.[15] Additionally, the effect of audit and feedback varied significantly based on the frequency of the intervention, HCP baseline performance and complexity of the desired behaviour.[15] Similarly, the effect of educational meetings and workshops, such as courses and conferences, had a comparable effect to EOVs and audit and feedback. Forsetlund et al. concluded that educational meetings and workshops, whether used alone or in combination with other interventions, improved HCPs' compliance with the desired practice by 6%.[12] On the other hand, printed educational materials, such as journal publications, were shown to be the least effective with only 2% improvement in HCP practices.[17]

1.3 Computer-based education: a promising approach

The COVID-19 pandemic has limited the application of behaviour change interventions that require travel and face-to-face interactions such as educational meetings and academic detailing. As such, there is great interest in computer-based education (CBE) which is gaining popularity in enhancing HCPs' accessibility to training and education. The evidence is growing that educational activities that are self-directed, interactive, address learning needs, use different delivery options (e.g., demonstration, feedback, case-based learning) and focus on specific objectives are more

successful in promoting behaviour change.[18,19] Hence, CBE is a promising approach to support pharmacists in improving their performance. In light of time constraints and geographical boundaries, together with improved access to software and technology, CBE shows a clear advantage over traditional education methods. With many pharmacists located in rural and remote locations and others who may not be able to take time off work for traditional training, CBE offers a highly engaging, easily disseminated, flexible delivery method for education and training. However, most research on CBE tends to focus on student education rather than HCP education. There is limited evidence comparing CBE to other interventions such as printed education material or workshops. Furthermore, more understanding is needed on how to best deliver educational content via CBE to achieve the best learning outcomes and promote behaviour change for HCPs.

1.3.1 Computer-based education definition and characteristics

CBE is defined as "the delivery of educational content through information and communication technologies"[20] using a wide range of design features such as discussion boards and case studies. The term CBE has been used interchangeably with the terms e-learning, web-based learning, online learning, online education, internet-based learning, multimedia learning, technology-enhanced learning and virtual learning.[20,21] Cook et al. explained that there are two things central to CBE: 1) the use of the internet; and 2) the use of a computer to support or replace the instructor.[22]

CBE offers a wide range of characteristics for development and delivery of educational content. For example, CBE can be designed to deliver content through internet alone as a fully online program to maximize learners' independence, or as part of blended program with face-to-face learning.[23] Moreover, CBE can be designed to enhance collaboration where users communicate through discussion forums, or to support self-directed learning.[24] Content can also be delivered in a synchronous or asynchronous way. Synchronous CBE allows users to interact

with instructors and other learners in real time, while asynchronous CBE does not depend on interaction between learners and allows for more flexibility with time.[25] CBE also allows the delivery of standardized material to a large number of users in the same location or at multiple locations at the same time.[24,26]

1.3.2 Computer-based education for HCPs: advantages and drawbacks

HCPs are expected to stay updated and maintain their competence to succeed in a dynamic work environment where best practices are constantly changing. As such, CBE offers several advantages in training HCPs. First, CBE has the potential to deliver flexible educational packages with content that can be easily updated and modified to keep HCPs informed.[26,27] It provides easy access to unlimited resources which also makes it ideal for HCPs working in rural settings.[24] It allows users to tailor content to their needs by focusing on topics of interest and skipping topics they feel they already have adequate knowledge in.[28] It also allows users to interact and connect with peers and experts.[24] Studies have shown that CBE can reduce training costs by 50% compared to traditional training due to a reduction in travel costs, instructor supervision and teaching space.[24,26]

Despite the advantages of CBE, there are a few drawbacks, especially with fully online versions (e.g., non-blended). For example, there are concerns that CBE maybe associated with learner isolation due to lack of face-to-face interaction with peers. Maintaining peer networks has a significant role in professional development and shaping professional attitude especially for rural HCPs and new healthcare graduates.[29] Moreover, CBE may limit the ability of instructors to respond to questions especially in asynchronous learning, which can lead to lower learner satisfaction.[30] There are also concerns about more distractions while learning as most users access CBE education at home. Inadequate digital literacy and unreliable internet access are other concerns that can lead to a high dropout rate.[20,21,26,28] As such, research suggests that using a

blended approach that combines CBE with traditional learning maybe more effective than fully online CBE and may better balance the benefits of traditional learning with the flexibility of online learning.[26,31]

1.3.3 Computer-based education impact

CBE is becoming an integral part in undergraduate education, postgraduate training and continuing professional development.[24] Several studies have explored the use of CBE in healthcare education where mixed results were reported. Overall, it was shown that CBE is more effective than no intervention and at least as effective as traditional learning in improving HCP knowledge, skills and behaviour.[26,32-36] A 2018 review by Vaona et al.[37] on the effect of e-learning on licensed HCPs compared to traditional learning (face-to-face learning and printed educational material) included 16 randomized trials. All studies included physicians or nurses. The review reported that e-learning has little effect on HCPs' behaviour and on patient outcomes. Moreover, the review also suggests that e-learning has a similar effect on skills and knowledge compared to traditional learning. Similarly, a review of the effectiveness of e-learning in pharmacy education by Salter et al.[34] reported that e-learning produced an equivalent effect on knowledge compared to traditional learning immediately after e-learning. However, there is no evidence that e-learning can improve skills or produce a long-term change in knowledge. Furthermore, a few studies have suggested that fully online CBE could be associated with poorer outcomes for HCPs compared to traditional learning due to lack of face-to-face interaction and higher dropout rates.[26,37]

1.3.4 Computer-based education design features

With the rapid shift toward CBE, it is critical to understand design elements and how they affect learning outcomes, particularly behaviour change. However, only a few studies of relatively poor quality investigated which features can maximize effectiveness, and how to best design CBE for

HCP education.[21,24]Cook et al.[38] suggested that practice exercises, repetition, and feedback could enhance learning outcomes for HCPs, while online discussions could enhance HCP satisfaction. Similarly, Scott et al. suggested a number of features that should be considered when designing CBE for HCPs including role play and virtual patients to practise skills; online discission boards to enable interaction among HCPs; and adding motivators to retain users such as offering a certificate of completion.[24] Scott et al.[24] also proposed some useful tips to enhance knowledge gain with CBE including incorporating case-based quizzes, feedback, practice assessment and adaptive learning. However, Scott et al. reported that including more interactive elements does not necessarily lead to higher knowledge gain. Carroll et al.[39] conducted a systemic review of qualitative studies assessing HCP experience with CBE. The review reported a number of key design features to enhance learning outcomes with CBE such as the use of real-world case studies that are relevant to daily HCP activities; availability of education material in a downloadable format to maximize flexibility; peer interaction through discussion boards; tutor support via email; and assessment of knowledge via tests and quizzes. Moreover, Morrison et al.[40] suggested crucial design features for CBE including: social support features to provide peer-to-peer interaction (e.g., discussion forum); features to enhance contact with the intervention (e.g., instant messaging, reminder emails); and self-management features (e.g., self-assessment, and self-monitoring). The heterogeneity in instructional design features indicates a lack of consensus on the best design features to improve learning outcomes, and that different design features might be needed for different topics.[33]

1.3.5 Gamifying computer-based education: a future opportunity

Evidence suggests that CBE might be more useful for gaining and reinforcing knowledge than face-to-face learning, but less useful in practising skills or changing behaviour.[20] However, it is

suggested that using gamification by adding game elements such as storytelling could enhance engagement with CBE and provoke deeper learning that can influence behaviour.[20,41,42] Gamification is defined by Deterding et al.[43] as "the use of game design elements in non-game contexts". As such, gamification uses a combination of game elements such as points, badges and leaderboards to create an engaging experience for users.[44] Gamification has been applied in different domains including education, training, and health.[45] It has yielded mostly positive results, especially in terms of encouraging users' participation, enhancing engagement, and provoking behaviour change.[46-48]

An interesting feature about gamification is the ability to promote behaviour change by increasing users' intrinsic motivation using deeper game elements other than points and badges. Intrinsic motivation is defined as the tendency to engage in an activity because it is satisfying or enjoyable.[49] Based on the Self-Determination Theory,[50-52] gamification elements can make users more intrinsically motivated by satisfying three psychological needs: 1) autonomy: the need to feel free and able to act without external pressure;[53-55] 2) competence: the need to feel efficient and mastering a certain behavior;[56] and 3) social relatedness: the need to feel connected with others.[49,51,57] An example of a game element that can address autonomy is a story based on real-life situations, which can increase users' immersion with game events.[52,57-59] Feedback and challenges through case studies are examples of game elements that can address competence.[59] Incorporation of a team is an example of a game element that can address social relatedness. A team can be a group of users, whether real players or virtual characters, working together to achieve a certain goal, which can enhance competition and cooperation.[52,57-59] As such, gamification is not just about simply adding superficial game elements such as points and badges to a platform and automatically expecting the platform to motivate and engage users. Deeper game elements, such

as stories, are more likely to target intrinsic motivation and hence may lead to a long-term change in behaviours.[60]

1.4 Pharmacy5in5 overview

Pharmacy5in5.ca is an asynchronous CBE platform designed to accelerate the adoption of best practices by pharmacists. *Pharmacy5in5* was created by a multidisciplinary team of pharmacists, graphic design artists, medical editors, and other experts in fields of adult learning. The platform is designed to release modules at regular intervals, each covering five take home messages about a clinical or practice topic. Each module has the following design components: one fast facts quiz, six case-based quizzes, immediate and delayed feedback, multimedia resources, peer comparison, and self-reflection questions. Since launching in 2018, *Pharmacy5in5* has been adopted by more than 13,000 pharmacy professionals across Canada, with participants from Ontario comprising 83% of the usership.

Pharmacy5in5 was used to conduct **Chapters 3** and **4** of the thesis. For further details about the platform please see Chapter 4, section 4.3.4.1 page 106

1.5 Statement of problem

There is limited understanding of the full impact of CBE, with most evaluations targeting CBE focused on user engagement and satisfaction.[26] Moreover, evaluation of the use of CBE in experienced HCP users, especially fully online asynchronous learning is lacking. Furthermore, research assessing the design and development of CBE is often of poor quality due to the limited number of randomized controlled studies reported.[21] Likewise, when randomized studies were reported, insufficient details were provided about the intervention or design features incorporated.[38,61] Therefore, it is vital to evaluate all levels of learning outcomes with CBE including knowledge gain, implementation and practice change. Moreover, evaluation of barriers

and facilitators to implementation should be also included.[62] More rigorous, theory-based evidence is needed to draw a definitive conclusion about the effectiveness of CBE on the knowledge and behaviour of experienced HCPs.

1.6 Thesis objectives

This thesis aims to refine and evaluate the effect of the CBE platform, *Pharmacy5in5,* on Canadian pharmacists' knowledge and behaviour. The first objective is to explore the literature to identify possible theories and design features used in the development of CBE. The second objective is to develop a theoretical approach to identify barriers of and facilitators to optimizing pharmacy professionals' behaviour. The third objective is to conduct a randomized controlled trial to assess the effectiveness of the *Pharmacy5in5* platform on pharmacists' knowledge compared to traditional learning. See table 1-1 for specific research questions.

Table 1-1 Thesis research questions

1) What is the effect of fully online CBE on HCPs knowledge, skills, and behaviours?
2) What are the most common theories used in developing fully online CBE platforms targeting experienced HCPs?
3) What are the most common design features used in developing fully online CBE platforms targeting experienced HCPs?
4) Using a theoretical framework, what are the barriers and facilitators that influenced pharmacists' adoption of the full scope services?
5) Which behaviour change techniques (BCTs) can overcome identified barriers and facilitators?
6) Which BCTs can be translated into design features for *Pharmacy5in5*?
7) Is there a difference in knowledge gain between the *Pharmay5in5* intervention group and the control group?

1.7 Thesis outline

This thesis adopts a sandwich style and is composed of five chapters in total. Chapters 2, 3 and 4 are published journal articles.

Chapter 2 – Effects of computer-based education on health professionals' knowledge, skills, and behaviour: A scoping review

The results and learning from this chapter answer research questions 1,2 and 3

Chapter 3 –Identifying barriers, facilitators, and behaviour change techniques to the adoption of the full scope of pharmacy practice among pharmacy professionals: Using the Theoretical Domains Framework

The results and learning from this chapter answer research questions 4,5 and 6

Chapter 4 –Evaluating the effectiveness of the computer-based education platform, Pharmacy5in5, on pharmacists' knowledge of anticholinergic toxicity using a randomized controlled trial

This chapter emerged from the findings of Chapter 2 and answers research question 7

Chapter 5 – Discussion and Conclusion

This chapter summarizes the finding from Chapters 2,3 and 4 and discusses challenges with methodologies used, implications and conclusions.

Chapter 2

Effects of computer-based education on health professionals' knowledge, skills, and behaviour: A scoping review

This chapter is published as follows:

Hussein R, Lin EC, Grindrod K. Effects of computer-based education on health professionals' knowledge, skills, and behavior: A scoping review. Journal of the American Pharmacists Association. Volume 61, Issue 3, 2021, Pages e44-e68, ISSN 1544-3191 ©Elsevier

https://doi.org/10.1016/j.japh.2021.01.036.

2.1 Overview

Background Computer-based platforms are rapidly growing as a promising way to deliver education to health professionals (HPs). However, evidence to support the use of computer-based education to change professional behaviour and clinical practice and to guide the selection of design features of computer-based educational platforms is lacking in the existing literature.

Objectives To address the current gaps in knowledge, a scoping review approach was used to explore the effects of computer-based education on HP knowledge, skills, and behaviour as the primary objective. A secondary aim was to determine design features of computer-based educational platforms that enhanced user satisfaction.

Methods The scoping review was conducted using the Arksey and O'Malley framework and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews. Relevant studies were first identified through searches in seven scientific databases. Studies were then selected through independent screening by two reviewers. Finally, the data of selected studies were extracted and charted using Excel (Microsoft Corporation).

Results Seventeen studies were selected for inclusion. The included studies were conducted on a wide range of HPs and used computer-based educational platforms with varying features, duration, clinical content, and offerings of accreditation. All studies reported at least one of the following outcomes: HPs' acceptance, attitude, and satisfaction; knowledge and skills; and behaviour; however, none of the studies evaluated degrees of change in patient outcomes. Only two studies used theoretical frameworks to develop their platform, with mixed impact on effectiveness and consistent effect on satisfaction. In addition, the platforms employed newer features such as tailored feedback and instant messaging.

Conclusions Computer-based education can enhance HP knowledge, skills, and behaviour. Future studies should explicitly outline the features that further improve learning outcomes and construct their interventions around well-grounded theory to improve the effectiveness of computer-based education on changing HP behaviour.

Key Points

Background:

- Computer-based education, when compared with no intervention, is associated with large positive effects in learning outcomes of health professionals (HPs).
- Computer-based education has similar efficacy as traditional education in improving HPs' learning outcomes, although high levels of heterogeneity exist within the literature.
- There is insufficient evidence to provide recommendations about the theories and design features to incorporate to improve computer-based educational platforms.

Findings:

- Computer-based education is effective for improving HPs knowledge, skills, and behaviour, although improvements in knowledge do not necessarily translate to improvements in behaviour.
- Certain features of computer-based educational platforms may improve HPs behaviour; other features that do not directly improve behaviour may enhance user satisfaction and therefore increase uptake.
- The use of theory in designing computer-based educational interventions may not lead to an improvement in HPs' behaviours but may improve their satisfaction and engagement.

2.2 Introduction

Health professional (HP) behaviour plays a key role in patient care. Although proper health care practice improves patient outcomes, substandard health care practice contributes to poor care and patient harm.[63] Promoting professional behaviour change is therefore important; however, finding effective ways to encourage HPs to routinely provide high-quality, evidence-based clinical practice has proved to be a challenge.[64]

With the wide-scale availability of computers and the Internet and largely because of its simplicity of implementation, computer-based education has become an attractive and popular intervention for changing HP behaviour.[37,65] Computer-based education is broadly defined as "the delivery of educational content through information and communication technologies (ICT),"[20] although many variations to this definition exist. Also known as "e-learning," "online learning," "Web-based learning," or "multimedia learning," computer-based learning implements diverse instructional designs and delivery formats.[20] It employs a wide variety of features, which can range from traditional lectures to clinical simulations, games, and online discussion forums.[66] Computer-based learning has many advantages compared with traditional learning: it is easily updated, widely distributable, and flexible—it can deliver content at any time and from anywhere, which saves time and resources as well as reduces travel costs. It can also accommodate different learning styles, allow for self-paced learning, and enable a high level of user interactivity and engagement.[20,67]

Computer-based education has been widely implemented in health care education.[34,68] However, as previous reviews highlight, most research has been done with students and trainees. Only a few studies have evaluated the effect of computer-based learning on experienced HPs in practice; most of the studies are also of poor quality.[37,61] Furthermore, other existing reviews mostly focused on how computer-based learning enhanced interprofessional collaboration and therefore only included HPs in primary care teams or health care students rather than experienced HPs across all practice settings.[67,69]

Beyond effectiveness, to date, no review has explored how to select or combine the features of computer-based educational platforms to improve learning outcomes and user satisfaction or how to use theories to design educational platforms and select platform features. Of the few studies

that assess HP behaviour as well as investigate features to optimize computer-based educational platforms, evidence is lacking in both quantity and quality. For example, a 2010 systematic review and meta-analysis by Cook *et al.*[38] identified several features that educators can consider incorporating into their Internet-based educational interventions, such as practice exercises and feedback. However, owing to insufficient evidence, the strength of the recommendations was limited. Therefore, building on previous reviews, and taking into consideration the rapid shift toward online education with the coronavirus disease 2019 pandemic, a scoping review approach was used to fill the gap in knowledge regarding the effectiveness of computer-based education beyond knowledge and satisfaction, as well as to help guide designers' selection of features and theories to implement in future computer-based educational platforms. The primary objective of this scoping review was to determine the effects of computer-based education on the knowledge, skills, and behaviour of HPs (particularly those of pharmacists, physicians, and nurses). A secondary objective was to determine features of computer-based educational platforms and theories used in the design that enhance HPs' satisfaction.

2.3 Methods

This scoping review was conducted using the five-step framework outlined by Arksey and O'Malley[70]: (1) identify the research question; (2) identify relevant studies; (3) select studies; (4) chart the data; and (5) collate, summarize, and report the data. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews checklist[71] was also used for reporting the review.

2.3.1 Step 1: Identifying the research question

To determine the effects of computer-based education on the knowledge, skills, and behaviour of HPs (particularly those of pharmacists, physicians, and nurses), the following research questions were identified:

1. What are the effects of computer-based education on HPs' knowledge, skills, and behaviour?
2. Which features of computer-based education platforms enhance HPs' satisfaction?

2.3.2 Step 2: Identifying relevant studies

2.3.2.1 Search strategies

The search strategies were developed and revised by reviewers R.H. and E.L. with the aid of an experienced librarian for each of the electronic databases: PubMed, International Pharmaceutical Abstracts (IPA), EMBASE, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO, and Education Resources Information Center (ERIC) (Appendix A). The search strategies were then further refined with additional search terms through the reviewing of similar papers. Searches were then conducted between May 26, 2020 and June 1, 2020. Studies were not limited by date, location, or setting. Only studies published in English were included, whereas grey literature was not included.

2.3.3 Step 3: Study selection

After the execution of the search strategies, all search results were exported to Covidence, a systematic review software program (Veritas Health Innovation, Melbourne, AU, covidence.org), where duplicates were removed. Two reviewers independently screened the titles and abstracts as well as the full texts of the remaining studies in Covidence based on the basis of the inclusion and exclusion criteria. Studies were included if they specifically evaluated the effects of computer-

based educational platforms on the clinical knowledge, skills, or behaviour of HPs (pharmacists, doctors, or nurses). For this review, computer-based educational platforms were defined as those that distributed and facilitated access to clinical content primarily by the Internet, extranet, or intranet; for example, Web-based tutorials, virtual clinical vignettes, online discussion groups, Internet-mediated videoconferencing, Web seminars, e-mails, podcasts, and virtual social networks.[37] Studies were excluded if they clearly met at least one exclusion criteria (Figure 2-1). The Cohen kappa was used to measure inter-rater agreement for titles and abstract screening and for full-text screening. Disagreement was resolved through discussion with a third reviewer (K.G.).

- Used only slide-based presentations, CD-ROMs, or other applications not distributed through the Internet, extranet, or intranet as its intervention
- Used blended learning as its intervention
- Evaluated noneducational computer-based platforms or technologies
- Evaluated the effects of computer-based educational platforms on only patients, health professional students, or medical residents.
- Evaluated the effects of computer-based educational platforms on nonclinical knowledge, skills such as communication or management skills.
- Assessed only users' satisfaction, enjoyment, or engagement with computer-based educational platforms.
- Described only the development of computer-based educational platforms as its primary objective
- Described only the attitudes of health professionals toward computer-based education
- Reported lessons learned or recent trends in computer-based education
- Feasibility studies
- Qualitative studies

Figure 2-1 List of exclusion criteria applied during study selection

Abbreviation used: CD-ROMs, compact disc read-only memory.

2.3.4 Step 4: Charting the data

A chart was created using an Excel spreadsheet (Microsoft Corporation) to extract key data from the selected articles. The following categories of information were independently extracted from

each of the included studies by two reviewers*:* author(s), year of publication, country, study setting, study aims and objectives, study population(s), methodology (study design), computer-based intervention type and duration, features of the computer-based intervention, whether the computer-based intervention is accredited as an educational program, theoretical framework used, outcome measures, results of the computer-based intervention, and study conclusions. The data extraction chart was continually updated as articles were reviewed through the adding of new categories. Where articles cited a theory or the development of their platform in separate article, the original article describing the theory or development process was obtained.

2.3.5 Step 5: Collating, summarizing, and reporting the results

To present a narrative account of findings, a numeric analysis of the extent and nature of included studies was depicted using tables. In addition, the assessment of outcomes of the included studies were organized into the four levels of the Kirkpatrick Model:[72]

- Level one reaction: the degree to which participants find the computer-based intervention satisfying and engaging;
- Level two learning: the degree to which participants acquired knowledge, skills, confidence, and commitment by engaging with the computer-based intervention;
- Level three behaviour: the degree to which participants applied the acquired knowledge and skills; and
- Level four results: the degree to which patients benefited from participants' improved behaviour.

2.4 Results

2.4.1 Overview

Running the search strategies through the databases yielded a total of 7013 relevant studies (Figure 2-2), with 1611 studies being removed as duplicates. Two reviewers independently screened the titles and abstracts of the remaining 5402 studies using Covidence, after which 5172 studies were excluded. Of the 230 studies that underwent full-text screening, 213 studies (93%) were excluded. The most common reasons for exclusion were not meeting the definition for computer-based education or not examining knowledge, skills, or behavioural outcomes. This yielded 17 studies (7.4%) that met the inclusion criteria and were included in this review. The Cohen kappa was calculated to be 0.845 for titles and abstract screening and 0.799 for full-text screening, signaling a high level of agreement.

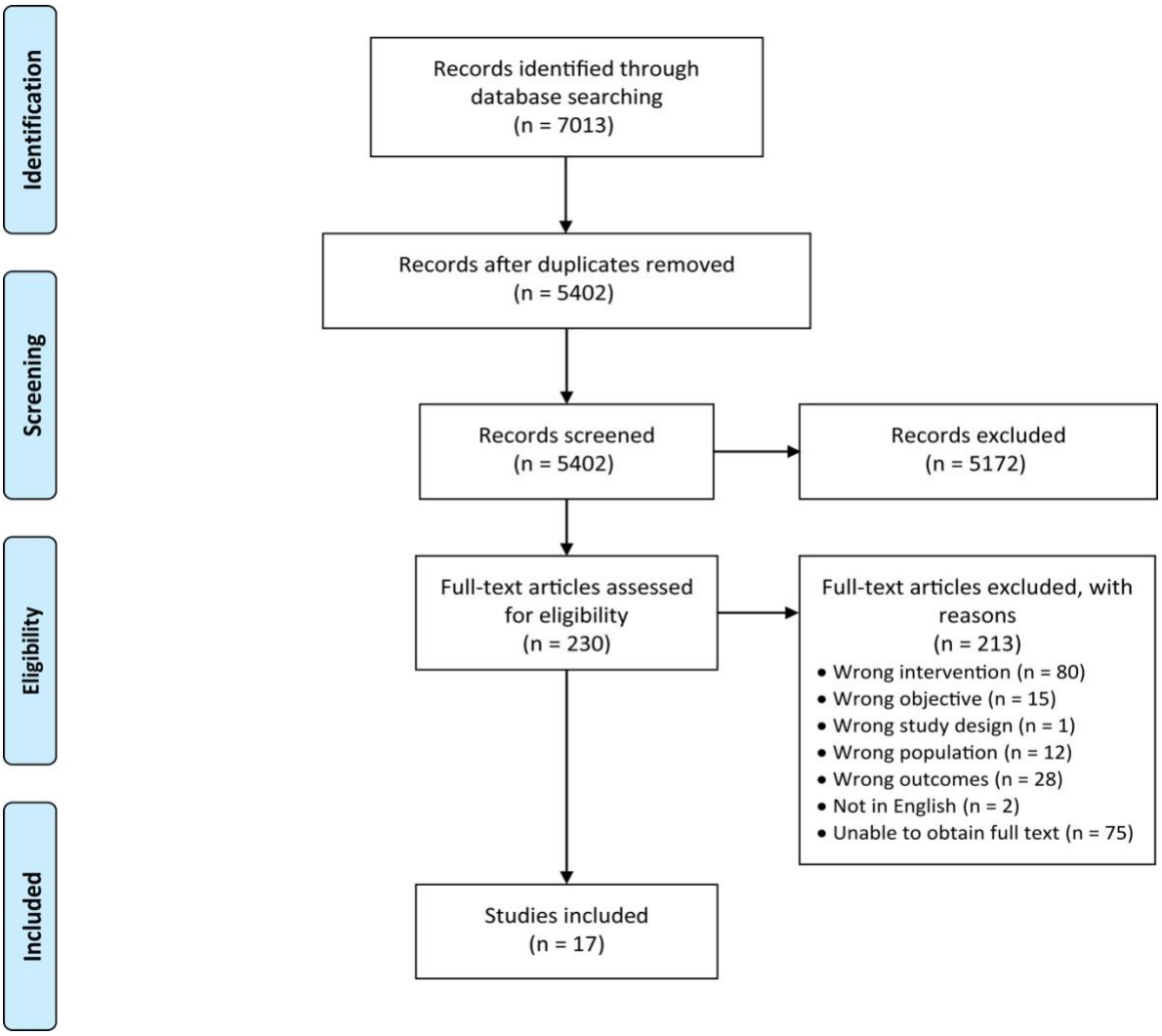

Figure 2-2 Flow diagram for scoping review process

2.4.1.1 Characteristics of studies

Of the seventeen included studies, computer-based educational platforms targeted a wide range of HPs: nurses (10 studies),[73-82] physicians (7 studies),[80,83-88] pharmacists (2 studies),[80,89] respiratory therapists (1 study),[73] and poison information specialists and toxicologists (1 study).[80] Four studies included mixed HP populations, 6 studies included nurses, 6 studies included physicians, and 1 study included pharmacists. The included studies were published between 2009 and 2019. Five studies took place in the Netherlands,[76,81,83,84,86] five in North America (four in the United

States[73,85,87] and one in Canada[77]), and three in Australia.[74,75,80,90] The remaining studies were conducted in Poland,[89] Korea,[78] Spain,[79] Uruguay,[88] and Iran.[82] Research methods included quasi-experimental (8 studies),[75,80,82,83,85,86,88,89] randomized controlled trial (8 studies),[73,74,76-79,81,87] and observational (1 study).[84] Table 2-1 provides the references and key characteristics for all included studies, specifically the aim, population, type of computer-based educational platform, methodology, features, and key findings (Appendix B for the full data extraction chart).

Table 2-1 Characteristics of included studies

Year	Authors; country	Aim and objective	Study population	Computer-based intervention	Methodology		Features	Key findings
					Study design	Intervention and control group		
2019	Sinclair *et al.*[90]; Australia	To evaluate the effect of a Web-based e-learning module on general practice nurses' behavioural intentions regarding CKD screening, knowledge about CKD risk factors and screening practices, as well as their satisfaction with the module	General practice nurses	CKD DETECT:Web-based e-learning module	Randomized controlled trial	Intervention: tailored behavioural e-learning module (i.e. module two) Control: knowledge-based active control e-learning module (i.e. module one)	Case studies, videos, assessment questions, preknowledge quiz, feedback, others (video transcripts, interactive links, multimedia, images and audio files)	Demographics: mean age 47 y; 99% women. Knowledge about CKD risk factors: participants' CKD knowledge scores significantly improved (from 3.77 mean pretest score to 5.48 mean posttest score; mean difference 1.81, $P < 0.01$). However, overall scores remained inadequate. Behavioural intentions: direct assessments of behavioural intentions to initiate a kidney health check found that there were no significant differences (P 0.424, [d] 0.04) in behavioural intention between

								the intervention and control groups at follow-up, when controlling for baseline values.
2019	Bentley *et al.*[75]; Australia	To describe the effect of the DCTEPon knowledge, confidence and attitudes, and behavioural intentions	Practice nurses and international medical graduates	DCTEP online program	Pre-post study	No control group	Videos, additional resources, discussion forum	Demographics: of the 18 PNs: median age 45 y; 17 women and 1 man. Of the 15 international medical graduates: median age 40 y; 8 women and 7 men. Dementia knowledge: participants' knowledge about dementia increased after completing the modules. DKAS mean scores increased by 10% (from 39.7 to 43.7) for international medical graduates and by 28% (34.1 to 43.6) for PNs. Behavioural intentions: Participants had strong intentions to apply a systematic framework to identify and manage dementia.

								Overall, this project demonstrated some early changes in clinical behaviour around dementia care.
2018	de Ruijter *et al.*[81]; the Netherlands	To assess the effects of a computer-tailored e-learning program on practice nurses' adherence to smoking cessation guidelines	PNs	Web-based program on smoking cessation guidelines	Randomized controlled trial	Intervention group: e-learning modules with tailored feedback letters Control group: general modules (Same content for both groups)	Additional resources, discussion forum, feedback	Demographics: mean age 47.3 y; 97.8% women. Overall guideline adherence: Mixed linear regression analysis revealed a positive program effect on adherence for PNs with a more-than-average level of counseling experience (beta=.589;[95% CI 0.111-1.068]; PHolm-Bonferroni =.048). Step-based guideline adherence: mixed logistic regression analyses regarding adherence to individual guideline steps that, for PNs with less favorable scores on behavioral predictors (eg, low

								baseline self-efficacy) and high levels of counseling experience, the program significantly increased adherence.
2018	Lombardi *et al.*[88]; Latin America (Uruguay)	To describe the design, implementation, and results of these courses and to evaluate its impact on medical knowledge	Nephrologists (for course 1) and primary care providers (for course 2)	Online distance course on acute kidney injury (for both course 1 and course 2)	Pre-post study	Not found	Case studies, videos, additional resources, certificate of completion, discussion forum, assessment questions, feedback, others (electronic rounds, videoconferences)	Demographics: for course 1 (nephrologists): 46% were <35 y; 52% men. For course 2 PCPs: no age data; 61% women. *Course 1:*knowledge gain: the mean number of right answers was 5.87 and 8.01, respectively (P < 0.05), which can be considered as a gain knowledge equivalent to 36%. *Course 2:* no mention of measurement of changes in knowledge, skills, or behaviour for course 2.

2018	Ozturk *et al.*[86]; the Netherlands	To evaluate the course execution and the short term effects regarding geriatric knowledge, attitude, and confidence	Medical healthcare workers involved in geriatric surgery	Online course on perioperative management of elderly patients	Pre-post study	No control group	Case studies, videos, discussion forum, assessment questions, others (weekly e-mails with tips and extra learning goals)	Demographics: mean age 35 y; 66% women. Knowledge: MCQ test knowledge scores improved significantly from 49% to 65% (P < 0.005). A better attitude correlated with a higher total knowledge score in surgeons and surgical residents (*P* = 0.02).
2017	Wong *et al.*[80]; Australia	To investigate whether an online toxicology course could improve the knowledge of health professionals treating patients presenting with the results of poisoning	Health professional: emergency doctors, medical officers, physicians, pharmacists, poisons information specialists, toxicologists, medical students, nurses	The Global Educational Toxicology Uniting Project: online course	Pre-post study	Not found	Case studies, additional resources, discussion forum	Demographics: median age 34 y; 54% men. Difference in MCQ score pre- and postmodules (primary outcome): median MCQ scores improved significantly from 56% premodule [95% CI: 38%–75%] to 89% [95% CI: 67%– 100%] post-module (*P* < .000). Final quiz scores (i.e. knowledge retention) (secondary outcome):

								Final quiz scores of 86% was significantly improved from overall median premodule MCQ score (IQR: 76%–92%) ($P < .000$). No. of participants who felt course changed their clinical practice and rating of modules (secondary outcome): 66 (65%) responders thought the course had changed their clinical practice so far (1 mo post-cessation) and 35 (35%) thought it had not.
2017	Bos-Bonnie *et al*.[84]; the Netherlands	To evaluate if an online e-learning module on STIs has a lasting, positive effect on knowledge, attitude, and behavior	General practitioners	The STI-consultation: online e-learning module	Prospective cohort study	No control group	Case studies, videos, follow-up questions, others (e-mail reminders of participants' intended practice changes)	Demographics: mean age 38.9 y; 66.4% women. Knowledge and attitudes toward STI: the knowledge and attitude of the participants improved (improvement was statistically

								significant for 5 of the 11 questions), which persisted up to two y after completing the program. Changes in clinical practice (i.e. behaviour toward STI): the participants reported that 34.3% of the intended changes was fully implemented, 62.9% was partially implemented, and 2.8% was not implemented
2015	Nesterowicz *et al.*[89]; Poland	To compare remote courses to on-site courses based on knowledge change and level of acceptance	Pharmacists	E-learning course on proper monitoring of blood pressure and chosen laboratory parameters Important for patients with hypertension	Pre-post study	Intervention group: remote course Control group: on-site course taught conventionally (Same content and communication among one another and with a tutor allowed for both groups)	Discussion forum, feedback	Demographics: for intervention group: average age 39 y; more women than men. For control group: average age 45 y; more women than men. Knowledge changes and/or increase: the increase of knowledge within each group before and after the course was significant (Wilcoxon Rank:

								control group: Z value= -11.12, $P < 0.001$; Intervention group: Z value= -19.32, $P < 0.001$). However, the groups did not differ significantly in change of knowledge: the mean percentage of total changes in knowledge score was 29.0% (SD = 16.4) and 27.2% (SD = 19.2) in intervention and control groups, respectively
2014	Kim and Shin[78]; Korea	To test the effectiveness of an online PBL program that offers multimedia scenarios to develop sexual health care competencies	Oncology nurses (RNs)	Online PBL e-PBL program on sexual health care	Pretest-posttest randomized controlled trial group	Intervention group: received e-PBL program Control group: did not receive e-PBL program or any additional education	Case studies, videos, additional resources, discussion forum, assessment questions, others (chat, file downloading and uploading tools, bulletin-board system)	Demographics: mean age 33.66 y (no gender data). SHC knowledge (primary outcome): nurses in the intervention group scored significantly higher on knowledge than those in the control group. SHC practice (primary outcome): the intervention group exhibited no significant

								differences in practices after the intervention.
2014	Van de Steeg *et al.*[76]; the Netherlands	To investigate whether offering nursing staff an e-learning course in delirium care increased their adherence to the Frail Elderly Project guideline and their delirium knowledge	Hospital nursing staff	E-learning course on delirium clinical features, risk factors, diagnosis, prevention, and treatment	Stepped wedge cluster randomised trial	No control group (stepped wedged design where participating hospitals crossed over from the control to intervention phase)	Case studies, certificate of completion, assessment questions	Demographics: mean age 35.7 y; 6.7% men. Percentage of older patients screened for delirium risk (primary outcome): the e-learning course had a significant positive effect on nursing staff's risk screening of older patients (odds ratio 1.8, $P < 0.01$), as well as other aspects of delirium care. The number of patients diagnosed with delirium was reduced from 11.2% in the control phase to 8.7% in the intervention phase ($P = 0.04$). Changes in delirium knowledge (secondary outcome): the e-

								learning course showed a significant positive effect on nurses' knowledge of delirium. The corrected average score improved from 79.6% [CI 78.9 –80.4] for first test to 88.6% [CI 88.0 – 89.2] for second test.
2014	Moattari *et al.*[82]; Iran	To validate a Web-based diabetes education program on nurses' knowledge and clinical competency in diabetes, and nurses' perception about its usability and quality	Licensed nurses	Web-based program provided through learning management system on diabetes	Pre-post study (single group quasi-experimental design)	Not found	Videos, additional resources, discussion forum, assessment questions, feedback, others (animated slides, images, video sequences, forms, tables and charts with synchronized narrations, ability to send or receive messages, display of online status)	Demographics: mean age 36.3 y; 100% women. Diabetes knowledge: the mean diabetes knowledge score increased from 11.26 ± 0.834 at baseline to 17.47 ± 0.607 after Web-based education ($P < 0.001$). Results of paired *t* tests in all modules, except the foot ulcers module, showed significant changes in knowledge scores. Diabetes competency (i.e. "skills"): nurses' competency score

								prior to Web-based education was 9.13 ± 1.60 out of 20 which increased to 15.27 ± 1.50 after the intervention (*P* < 0.001).
2013	Gordon *et al.*[73]; United States	To increase nurses' tobacco cessation intervention behaviors, positive attitudes, and self-efficacy in providing tobacco cessation interventions to patients	Practicing pediatric respiratory therapists, registered nurses, and nurse practitioners	WeBREATHe: Web-based course	Randomized clinical trial	Intervention: immediate access to WeBREATHe Control: delayed access to WeBREATHe	Case studies, videos, additional resources, certificate of completion, discussion forum, assessment questions	Demographics: mean age 36 y; 88.3% women. Behaviours: participants in training condition were more likely to increase their tobacco cessation intervention behaviors than their delayed training counterparts (F[1, 213] = 32.03, *P* < 0.001). Training participants showed significantly greater levels of each of the "5 A's", particularly assist/arrange (F[1, 213] = 35.52, *P* < 0.001).
2013	Rankin *et al.*[77]; Canada	To determine the impact of a Web course on RNs' triage skills using the CTAS	Registered nurses in the emergency deperatment	Online course on the CTAS	Randomized trial	Intervention group: 1) mandatory tutorial, 2) marks for online	Online discussion forum supported by a course facilitator, case studies	Demographic information: Most of the respondents were women aged

						discussion, and 3) triage workplace project Control group: 1) tutorial recommended but not required, 2) no marks for online discussion, and 3) no workplace project (Same content and learning activities for both groups)		between 35 and 54 y. Changes in clinical practice: of the 367 charts audited, 69.8% (n = 256) were identified as correctly triaged by the emergency nurse expert. The accuracy rate was 72.1% (n = 132) for the intervention group and 67.3% (n = 124) for the control group. Although [the authors] believe this difference to be clinically significant, a Fisher exact test showed that the difference was not statistically significant (*P* = 0.36).
2013	Eide *et al.*[85]; United States	To develop an interactive Web-based course to improve the skin cancer skills, diagnosis, management, and practice in	Primary care providers	Internet Curriculum for Melanoma Early Detection: Web-based course	Pre-post study	Intervention group: case-based format with case vignettes Control group: traditional textbook format	Case studies, assessment questions, feedback, others (clinical images)	Demographics: mean age 50.5 y and ranged from 30 to 68 years; 54% women. Competence (i.e. "skills") and performance: For all 3 score categories,

		primary care providers				(Both formats contained same topics) Note: Participants were able to choose one of the 2 learning formats		immediate pos-ttest scores were significantly higher than pretest scores. Scores for the 6-m post-test declined from those of the immediate posttest but in general remained higher than pretest scores. Effect of course on clinical performance: there was no increase in dermatology use for suspicious lesions after the skin cancer training. From late 2010 to late 2011, referrals to dermatology decreased. Skin biopsy rate and skin cancer diagnoses were comparable at both sites.
2012	Hugenholtz *et al*.[83]; the Netherlands	To design an electronic EBM course, and to study the feasibility and utility of the course as well	Occupational physicians	E-learning course on EBM topics	Within-subjects study with pre- and post-test evaluation	No control group (a reported limitation of the study)	Additional resources, feedback, others (assignments, help files)	Demographics: 60% under 40 years; 50% women. EBM knowledge: The electronic EBM course has an overall significant

as its effectiveness in increasing EBM knowledge, skills, and behaviour		effect on the occupational physicians' knowledge of EBM and their self-efficacy on practicing it ($P <$ 0.01 and $P = 0.02$, respectively). EBM skills: the overall effect of the intervention on the enhancement of EBM skills is not significant, but the skills are enhanced substantially immediately after course completion and, although they decline, are still higher at 2 m after course completion compared with baseline. EBM attitude, behaviour, and determinants of behaviour: the initial high scores on attitude remain stable over time. No significant effect was found on EBM behaviour

								and determinants of behaviour. Evidence use: after the course, more occupational physicians use the international journals to solve a case.
2011	Pelayo *et al.*[79]; Spain	To measure the effectiveness of an online module regarding knowledge and attitude toward PC, and physicians' satisfaction in comparison with that of a control group	Primary care providers	Online e-learning module on palliative care management	Randomized controlled educational trial	Intervention group: had access to online program for palliative care self-training Control group: no access to the online program, but could voluntarily receive traditional training (i.e. the usual PC training offered in working area)	Videos, discussion forum, assessment questions, feedback, others (images, diagrams, interactive Web pages)	Demographics: for intervention group: mean age 48 y; 44% women. For control group: mean age 47 y; 46% women. Palliative care knowledge: There were significant differences in favor of the intervention group in terms of knowledge (mean 4., [95% CI: 2.8 – 6.5], $P = 0.000$)
2009	Kerfoot *et al.*[87]; United States	To investigate whether ISE could significantly improve knowledge, and to determine	Urologists and urology residents	ISE (a type of online education) on hematuria and priapism for cohort A and staghorn	Randomized controlled trial	Intervention group: had completed 2 cycles for ISE program at time of presenting	Case studies, assessment questions, feedback	Demographics: mean age 47 y; most were men Clinical practice guideline knowledge difference (primary

	whether ISE is an acceptable form of graduate and continuing medical education	calculi, infertility, and antibiotic use for cohort B	cycle 3 (intervention group is split into cohort A and cohort B) Control group: presented with material for the first time at time of presenting cycle 3	outcome) during the ISE course, scores (MCQ) for both cohort A and cohort B increased from cycle 1 to cycle 2 to cycle 3. Compared with cycle 3 control scores, the ISE course significantly increased absolute scores and relative scores in both cohorts ($P <$ 0.001).

Abbreviations used: CKD, chronic kidney disease; CTAS, Canadian Triage and Acuity Scale; DCTEP, Dementia Care Training and Education Program; DKAS, Dementia Knowledge Assessment Scale; PBL, problem-based learning; EBM, evidence-based medicine; IQR, interquartile range; ISE, interactive spaced education; MCQ, multiple-choice questions; STI, sexually transmitted infection; WeBREATHe, Web-based Respirator

2.4.1.2 Characteristics of computer-based educational interventions used in included studies (*features, accreditation, and theoretical frameworks*)

All authors of the included studies identified their computer-based educational interventions as Web-based e-learning courses or platforms. Specific subtypes of computer-based interventions were interactive spaced education (ISE)[87] and online problem-based learning.[78] The time required to complete the educational content within computer-based interventions varied, with the shortest duration being 1-3 hours[73,75,83-85] and the longest duration being 6 months.[81,89] Thirteen studies clearly reported that the participants involved had the freedom to complete the educational content at their own pace.[73,74,76,79,81-83,85-89] The remaining were unclear. Three studies reported that their computer-based educational intervention was introduced to participants at work.[76,78,85] Three studies clearly explained that the participants used their personal computers.[83,85] The remaining studies did not provide this information

The most common features used in the computer-based intervention were discussion forums (11 studies),[73,75,77-82,86,88,89] assessment questions (10 studies),[73,76,78,79,82,85-88,90] case studies (11 studies),[73,74,76-78,80,84-88] videos (9 studies),[73-75,78,79,82,84,86,88] feedback (9 studies),[74,79,81-83,85,87-89] and additional resources (8 studies).[73,75,78,80-83,88] Only three studies offered a completion certificate.[73,76,88] Five studies offered accreditation for continuing medical education (CME) and CME credit hours ranged from 2 to 15.[73,79,84-86]

In terms of the use of theoretical frameworks in developing computer-based educational interventions, only two included studies explicitly mentioned the underlying theory used.[81,90] de Ruijter *et al.*[81] used the I-Change Model (ICM) to develop the content of modules and to assess practice nurses' adherence to smoking cessation counseling guidelines using behaviour predictors.

According to the ICM, predictors of behaviour include attitude, awareness, knowledge, subjective norm, self-efficacy, and intention.[91] Another included study by Sinclair *et al.*[74,90] used the behavioural constructs of the theory of planned behaviour (TPB) to assess practice nurses' intentions to initiate screening in people at risk of chronic kidney disease. The TPB constructs, including behavioural beliefs, subjective norms, and perceived behavioural control, were used to assess behaviour intention—a valid proxy for behaviour.[92]

2.4.2 Outcome assessment

Reported outcomes of the included studies were classified into the 4 levels of the Kirkpatrick Model.[72] Of the seventeen studies included in the review, twelve assessed HPs' acceptance, attitude, and satisfaction with the computer-based interventions (Level one).[73-75,78,79,83-89] For example, Kerfoot *et al.*[87] used a survey to assess urologists' acceptance of ISE as a method of education. The study showed that ISE acceptability among the participants was high, with 84% indicating their interest in participating in ISE in the future. Similarly, Lombardi *et al.*[88] used a survey to assess nephrologists' and family physicians' satisfaction with an online multifaceted educational approach for acute kidney injury. The study found that 118 out of the 121 participants who answered the satisfaction survey were either satisfied or very satisfied. Moreover, the participants ranked features such as clinical simulation and videoconferences as the best components of the course. Of note, this was the only included study that assessed users' satisfaction with individual features of the computer-based intervention. The rest of the included studies all failed to assess users' satisfaction or engagement with individual features, and instead focused only on users' overall satisfaction with the entire intervention.

Level two of the Kirkpatrick Model includes knowledge, skills, and confidence. A total of fourteen of the seventeen studies assessed knowledge (Level 2) and showed a significant

improvement in knowledge gain (13 studies)[74-76,78-80,82-84,86-89] and knowledge retention (1 study).[80] Most studies assessed knowledge using multiple choice questions or true and false statements (8 studies).[74,79,80,82,83,86,87,89] Two studies used prevalidated knowledge scales.[75,78] Kim and Shin[78] used the Sexual Health Care Knowledge Scale to assess oncology nurses' knowledge gain. Bentley *et al.*[75] used the Dementia Knowledge Assessment Scale to assess nurses' knowledge. Surprisingly, only three out of the seventeen studies assessed skills, specifically evidence-based medicine skills,[83] skin cancer diagnosis skills,[85] and diabetes education skills.[82] Skills were assessed using Objective Structured Clinical Examination (OSCE) stations or test questions and images. For example, Moattari *et al.*[82] used ten OSCE stations to assess nurses' diabetes competency and demonstrated a significant improvement in nurses' competency score after taking Web-based education.

Behaviour or behaviour determinants (behavioural intentions) (Level three) were assessed in eleven of the seventeen included studies.[61,73,75-78,80,81,83-85] Behaviours were assessed using chart audit,[77,85] practice scales,[73,78] or commitment-to-change statements.[84,88] For example, Rankin *et al.*[77] evaluated changes in nurses' clinical practice of triage through auditing charts of patients admitted to the emergency department. Using an RCT, the study showed a higher accuracy rate of triage among nurses assigned to a 6-week Web-based Canadian Triage and Acuity Scale workshop, than among nurses assigned to a standard Web-based course (72.1% and 67.3%, respectively; $P = 0.36$). Although the difference was not statistically significant, the authors believed the change was clinically significant and helped transfer knowledge into practice. However, it was not clear how clinical significance was determined by authors. A study by Gordon *et al.*[73] assessed the effect of a Web-based tobacco cessation education program on respiratory therapists' and registered nurses' tobacco cessation-related behaviours using 15 items focusing on

the “5 A’s” (ask, advise, assess, assist, arrange). After 3 months of enrollment, the study showed that the participants in the intervention group were more likely to increase their tobacco cessation-related behaviours than the participants in the delayed intervention group. In particular, they showed a significant increase in all “5 A’s” behaviours except for the ‘ask’ behaviour.

Level four, the degree of change or improvement in patient outcomes, was not assessed in any of the included studies.

2.4.3 Outcome assessment based on profession

None of the studies with mixed HP populations described results on the basis of different professions. Of the studies including only nurses, four studies assessed knowledge, and all reported positive results,[74,76,78,82] one study assessed skills and reported positive results,[82] and four studies assessed behaviour change and reported mixed results.[76-78,81] Similarly, studies among physicians also reported positive results on knowledge (5 studies),[79,83,84,87,88] skills (2 studies),[83,85] and mixed results on behaviour change (4 studies).[83-85,88] One study recruited pharmacists only and showed significant positive effect on knowledge within groups.[89] However, the study did not assess skills or behaviour.

2.5 Discussion

In this scoping review, a total of seventeen studies were identified to assess the effect of computer-based educational interventions on HPs’ knowledge, skills, and behaviours. A key finding of this review was the promising effect of computer-based education on improving HPs’ behaviours, particularly on their adherence to practice guidelines. However, most studies used self-reported measures to assess behaviours, which could be prone to recall and social desirability bias, leading to inaccurate estimation of actual behaviours.[93-95] In addition, this review showed a positive effect

of computer-based education on HPs' knowledge and skills, with 82% of studies showing a significant knowledge gain and 67% of studies showing a significant improvement in skill acquisition. However, despite showing a positive effect of computer-based education on learning outcomes, the included studies failed to provide in-depth details about the theoretical framework used to develop the computer-based interventions, or the effect of selected features on HPs' satisfaction or learning outcomes.

This review identified two RCTs (Sinclair *et al.*, 2019[74]; de Ruijter *et al.*, 2018[81]) that were published after the 2018 systematic review by Vaona *et al.*[37] The RCT by de Ruijter *et al.*[81] assessed the effects of a computer-tailored e-learning program compared with no intervention on nurses' adherence to smoking cessation guidelines and showed significantly better guideline adherence. Furthermore, the study used a novel approach by providing nurses with individually personalized feedback on the basis of their answers to assessment questions, which may explain the positive effect on behaviour. This is in line with a previous Cochrane review of audit and feedback,[15] which showed that assessment of individual behaviour with feedback has a small but positive effect on overall behaviour. The RCT by Sinclair *et al.*[90] was also notable because it used a theoretical approach to evaluate the effects of a targeted behavioural online intervention on nurses' knowledge and behavioural intentions for chronic kidney disease screening practices, compared with a knowledge-based online intervention that did not use theory. Using features such as a prequiz to assess existing knowledge and videos to capture attention,[96] the study highlighted a significant improvement in knowledge and high satisfaction with the intervention content; however, there was no significant improvement in behavioural intentions. This suggests that improved knowledge does not necessarily reflect an improvement in behavioural intentions. This also suggests that using a computer-based intervention as a control group may not be suitable for

assessing changes in behaviours because it might mask the full effect of the intervention group on behaviours. This was also seen in the included study by Rankin *et al.*,[77] which also used a computer-based intervention as its control and showed no significant changes in nurses' actual behaviours.

This review highlighted a lack of a theoretical rationale when it came to selecting features of computer-based educational platforms. Newer studies used diverse features in their computer-based platforms, with the most common ones being discussion forums, feedback, instant messaging, and case studies, suggesting that these features are now more accessible to designers and easier for them to implement. However, none of the included studies reported the theoretical model used to guide the selection of design features and provide a better understanding of how the selected features help achieve the desired outcomes.[97,98] For example, the use of discussion forums to influence HPs' behaviour is supported by the social support theory and the self-determination theory. These two theories explain how discussion forums create a sense of social relatedness and identity, which can enhance HPs' intrinsic motivation to change behaviour, especially when HPs lack peer support in their practice settings.[99] Similarly, according to the self-regulation theory and the self-determination theory, feedback on progression can encourage positive behaviour change by enhancing HPs' sense of competency and self-efficacy.[99] Therefore, having a good understanding of the theory behind features can help explain why a particular computer-based intervention succeeds or fails in achieving behaviour change,[97,98] as well as facilitate the design of successful behaviour change interventions that are replicable.[100] Moreover, theory can link features with certain determinants of outcomes and allow for a better understanding of how discrete features contribute to outcomes when using a combination of features.

There are a few key limitations to this scoping review. Studies were restricted to the English language, which may have led to the exclusion of pertinent information written in non-English languages or published in non-English speaking countries. To restrict the volume of materials and maintain a focus on research studies, grey literature was also excluded from the searches and the analysis. As such, this review is less likely to have included studies that are relevant but unpublished owing to null findings, and therefore publication bias cannot be ruled out. Systematic reviews, meta-analyses, and qualitative studies were also excluded. Finally, the studies in this review were not critically appraised, and the quality of the included studies could therefore not be determined. However, it should be noted that the emphasis of scoping reviews is on comprehensiveness, rather than on meeting a particular quality of evidence.[70,101]

2.6 Conclusion

Overall, this scoping review demonstrated the effectiveness of computer-based education beyond knowledge and skills: it determined computer-based educational platforms to be a promising intervention in improving HPs' behaviours, particularly behaviours relating to guideline adherence. This review also suggested that adding features such as tailored feedback to computer-based interventions might improve behaviours, while adding features such as preknowledge quizzes and interactive videos might not affect users' behaviour but could improve users' satisfaction and uptake of the online interventions. Hence, features should be carefully selected according to the desired outcome of the computer-based intervention. In addition, using a theoretical approach to design interventions might not be enough to influence behaviours, but could improve satisfaction and engagement with computer-based interventions. In light of this, future research should seek to incorporate theory into the design of computer-based interventions, as well as clearly describe how theory can be translated into practical guidelines to direct the

selection of features. Moreover, future studies that report the use of theory to design interventions and select features should do so using detailed steps, such that the replication of intervention designs is possible.

2.7 Acknowledgements

The authors of this scoping review thank Caitlin Carter for providing guidance and assistance with building searches for the database

Additional context

- *Rationale for the study exclusion criteria*

This scoping review examined the effect of computer-based education (CBE) platforms on the knowledge, skills and behaviour of experienced HCPs. The review also aimed to identify common design features and theories used in designing CBE platforms targeting experienced HCPs.

In addition to the published methods described in the paper, some additional context may help to place this published paper in the context of the overall thesis. In this thesis, the goal of the scoping review was to identify published literature on stand-alone computer-based education (CBE) interventions. Specifically, this thesis aims to examine the role of fully online CBE on pharmacist knowledge and behaviour change using a fully online platform called Pharmacy5in5. Thus, in the scoping review, studies were excluded if they included non-online components such as blended CBE that included a face-to-face component, lectures or workshops. Moreover, studies that focused on assessing the effect of CBE on students only were also excluded as they did not answer the research question related to the effects of CBE on experienced HCPs. Furthermore, the two exclusion criteria (feasibility and qualitative studies) were added *post hoc* upon new familiarity with the studies during the study selection process. For example, most of the qualitative studies were targeting healthcare students, and focusing on satisfaction and user perception or experience with CBE. Moreover, identified qualitative studies did not assess behaviours change or reported theories used in the development of CBE platforms.

Overall, the inclusion/exclusion criteria were added to maintain a focus on fully online platforms targeting experienced users, as such relevant papers could have been missed.

Chapter 3

Identifying barriers, facilitators and behaviour change techniques to the adoption of the full scope of pharmacy practice among pharmacy professionals: Using the Theoretical Domains Framework

This chapter is published as follows:

Hussein R, Whaley CR, Lin EC, Grindrod K. Identifying barriers, facilitators and behaviour change techniques to the adoption of the full scope of pharmacy practice among pharmacy professionals: Using the Theoretical Domains Framework. Research in Social and Administrative Pharmacy. Volume 17, Issue 8, August 2021, Pages 1396-1406 ©Elsevier https://doi.org/10.1016/j.sapharm.2020.10.003

3.1 Overview

Background As pharmacy evolves, pharmacy professionals continue to struggle to practice to their full scope. A theoretically-informed intervention to change practice can support pharmacy professionals in providing full scope services. The Theoretical Domains Framework (TDF) can inform the design of a behaviour change intervention to improve the uptake of full scope services among pharmacy professionals.

Objectives This study aimed to: (1) identify barriers and facilitators influencing the adoption of full scope services among pharmacy professionals, and (2) identify optimal behaviour change techniques (BCTs) to address the identified barriers and facilitators.

Methods A three-step, mixed method study was conducted. First, a 21-item TDF-based survey was sent via email to users of a national computer-based educational platform (n = 2696). Second, TDF-based interviews were conducted with a convenient sample of survey respondents and analyzed using the framework method. Finally, validated linkages were used to link BCTs with corresponding barriers and facilitators, then interview data were analyzed using a deductive approach to guide the selection of the BCTs.

Results A total of 225 participants completed the survey and 24 telephone interviews were conducted (17 pharmacists, 7 pharmacy technicians). A number of key barriers were identified on an individual level (e.g., lack of clear professional identity and limited decision-making skills in ambiguous cases) and on an organizational level (e.g., lack of social support from managers and concerns about making more errors with the current workflow). Mapping the barriers and facilitators to BCTs yielded 18 BCTs to support the adoption of full scope services, including modeling, rehearsal/practice, and social support.

Conclusions This study highlighted several barriers that need to be addressed to facilitate pharmacy professionals working to their full scope, including professional collaboration, professional identity, and adequate training. A comprehensive intervention combining skills training with modeling, social support, and decision-making tools could encourage practice change.

Keywords: The Theoretical Domains Framework, pharmacy professionals, practice change, full scope

3.2 Introduction

In recent years, the role of the pharmacist has expanded significantly, shifting away from the traditional function of medication dispensing and evolving to a more clinical, patient-centered approach.[8] In Canada, the full scope of pharmacy practice varies across jurisdictions but ranges from independent prescribing, prescription adaptation, prescription renewal, to vaccine and drug injection and ordering and interpreting lab or point-of-care tests.[102,2,103]

The value of full scope pharmacy services has been established by several studies. For example, a 2018 Cochrane review[2] reported that pharmacist services provided in community and ambulatory care settings services can improve chronic medical conditions such as hypertension. Similarly, a 2016 review[104] focusing on prescribing services provided by pharmacists and other healthcare providers highlighted the positive effects of pharmacist prescribing services for a range of medical conditions such as hypertension, dyslipidemia, and diabetes. Moreover, several randomized controlled trials have shown that full scope pharmacy services prevent medication

errors and reduce the number of emergency room visits and associated healthcare costs.[5,105,106] It is estimated that drug-related costs could be reduced by $3.6 billion annually by pharmacy services in nursing facilities in the United States.[107] A 2014 economic evaluation review of pharmacy services estimated that, for every dollar invested in pharmacy services, there was a return of up to $25 in benefit.[6]

Yet, several studies have shown that the rate of adoption of the full scope of practice among Canadian pharmacists and pharmacy technicians has been much slower than expected.[8,103,108-110] In addition to a lack of time and staffing,[111-113] pharmacists themselves are also considered a major barrier to advancing practice due to reluctance and a lack of confidence, even when regulations are in place to support their growing role.[9,114-117] Regulations are one strategy to support change, but regulations alone are not be enough to support adoption.[112] Developing theoretically-informed tools to enable pharmacists to practice to their full scope has the potential to positively change the way pharmacists deliver care. Using a theoretical lens to understand factors that influence behaviours can improve understanding of possible techniques to change these behaviours, thereby enabling the development of more effective behaviour change interventions.[118,119] The Theoretical Domains Framework (TDF)[120] is a validated and comprehensive framework of theories designed to maximize the translation of established theories into practice. The TDF combines 128 theoretical constructs and 33 theories of behaviour change mapped to 12 domains: 'knowledge', 'beliefs about consequences', 'skills', 'behavioural regulation', 'social/professional role and identity', 'social influences', 'beliefs about capabilities', 'memory', 'attention and decision processes', 'motivation and goals', 'emotions', 'environmental context and resources', and 'nature of the behaviours'. The majority of domains relate to individual factors and personality traits that

impact change. The framework was originally designed to influence healthcare professionals' behaviour, particularly that of physicians and nurses,[121-124] to improve implementation of evidence-based recommendations. It has since been applied to a wide range of clinical behaviours across different clinical settings.[125]

A few studies have used behaviour change theories to investigate barriers to behaviour change among pharmacists and pharmacy technicians. For example, a study conducted in Alberta among pharmacists[111] used the diffusion of innovations theory to identify that the main barriers holding pharmacists back from using a new independent prescribing scope of practice were related to knowledge, confidence, and physician relationships. Another study conducted in Ethiopia[126] used the TDF to identify that knowledge deficits, inadequate training, and low awareness by other healthcare professionals were the main barriers for hospital pharmacists engaging in medication safety activities. Similarly, a study conducted in Nova Scotia[127] also used the TDF to identify that pharmacist prescribing was being held back by knowledge gaps, liability concerns, poor physician relationships, and limited reimbursement. Of these studies, none have used behaviour change theories to design behaviour change interventions or to identify strategies to facilitate the implementation of full scope services by pharmacy professionals. Compared to other behaviour change theories, the 12 domains of the TDF provide the most extensive coverage of potential barriers to and facilitators of full scope services implementation. Hence, the TDF has a greater capacity to build a behaviour change intervention that is more comprehensive and has a wider range of potential behaviour change techniques (BCTs) to address barriers and facilitators. Furthermore, mapping BCTs—defined as "observable components of an intervention designed to alter or redirect causal processes that regulate behaviour"[128]—to corresponding TDF domains help

maximize the benefit of a theory-based intervention by selecting optimal BCTs that can target pharmacy professionals' behavoiur.[129] By going beyond addressing factors that help or hinder the integration of Canadian pharmacy professionals' full scope into their daily practice, this study aims to select the optimal implementation strategies that can address identified factors and accelerate practice change. Therefore, our objectives were to use the TDF to identify barriers and facilitators to the adoption of the full scope of practice from the perspective of pharmacists and technicians, and then use these barriers and facilitators to identify optimal behaviour change techniques to help design a theoretically-informed behaviour change intervention to support practice change.

3.3 Methodology

We conducted a mixed method study that combined a survey with semi-structured interviews. Ethics approval was obtained from the University of Waterloo Ethics Committee (ORE #41548). As per the guide by Atkins et al.,[125] the study was designed based on the TDF and used the three-step approach (shown in Fig 3-1).

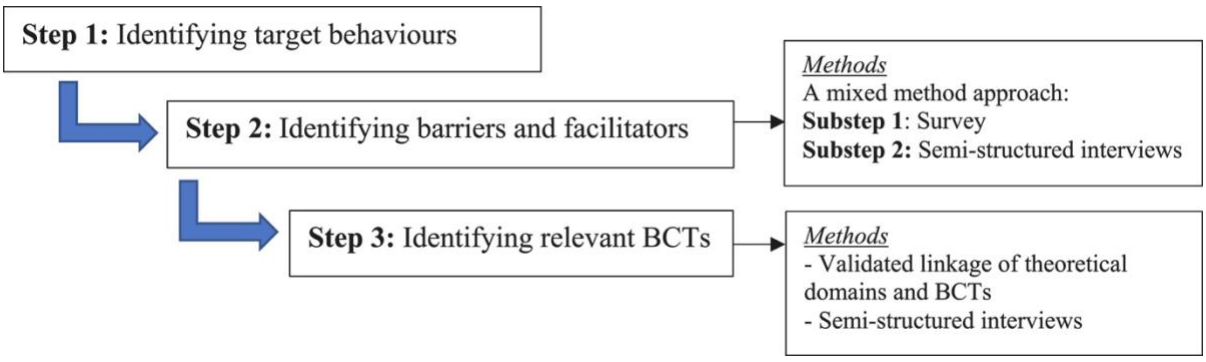

Figure 3-1 Overview of study steps from guide by Atkins et al.

3.3.1 Step 1: Identifying target behaviours

We started by identifying key behaviours of pharmacists and pharmacy technicians' full scope of practice, as the more specifically a behaviour is identified, the more precisely the barriers and facilitators can be addressed.[125] Using the Canadian Pharmacists Association's scope of practice document,[102] the following full scope behaviours for pharmacists were identified: independent prescribing, minor and common ailments prescribing, prescription renewal, prescription adaptation, administering injections and vaccines, ordering laboratory tests, and point of care testing, and the following full scope behaviours for pharmacy technicians were identified: independent technician checking of prescriptions and independent technician checking of non-sterile compounding. These behaviours were later used to develop the survey and the interviews.

Step 2: Identifying barriers and facilitators to the implementation of target behaviours

3.3.1.1 Population and recruitment

All registered users of Pharmacy5in5 (n = 2,696) —a national computer-based educational platform that combines game elements with behaviour change theories to accelerate the adoption of the full scope of practice by pharmacy professionals—who had identified that they were pharmacists or technicians practicing in Canada were invited to complete a short survey via email. Participants completing the survey were also asked to provide their contact information if they were willing to participate in the semi-structured interview. Reminder emails were sent at 14 and 21 days to increase response rate.[131,132] Using the list of willing interview participants, a convenient sample was selected. As outlined by Francis et al.,[29] interviews were conducted for the first 10 pharmacy professionals, after which they were conducted three at a time until no new ideas were

generated. All interviews were conducted by telephone by a single interviewer (RH) to ensure consistency, and were audio recorded, transcribed, and anonymized before analysis.

3.3.1.2 Instrument development

3.3.1.2.1 Quantitative data: Survey

The quantitative study was conducted using a 21-item, self-reported, anonymous survey designed using the 11 domains of the Theoretical Domains Framework (TDF). The twelfth domain, nature of the behaviours, is considered a dependent variable rather than an influencing factor and was not included.[120] The questions were adapted from a previously validated questionnaire by Huijg et al.[133] Participants' responses to the questions were assessed using a five-point Likert scale (1 = strongly agree; 5 = strongly disagree). Domains that had higher median scores signified a stronger barrier to behaviour change. Data on gender, years of experience, primary site of practice, and jurisdiction were also collected. To validate the survey for pharmacists' scope of practice, cognitive interviews were conducted with four pharmacists and one pharmacy technician using a think aloud protocol to assess comprehension and allow for clarification of ambiguous questions. Next, the survey was piloted by six practicing pharmacists. Once the survey was released, the sample size was calculated based on data from the first 50 responses using the following equation: $[1.96 \times (\text{standard deviation/desired error})^2]$. The standard deviation was estimated to be 2.7. Accounting for a standard error of 5%, the minimum sample size for the survey was estimated to be 112. A total of 225 participants completed the survey.

3.3.1.2.2 Qualitative data: Semi-structured interviews

The semi-structured interview guide was also developed based on the 11 domains of the TDF to provide an in-depth understanding of the identified barriers and facilitators. It included a list of prompts in case further elaboration on interview questions was needed, as well as allowed interview participants to share their insights on what tools and training they felt would be helpful in the future. The guide was refined based on the results of the quantitative study to focus on key behaviours and key TDF domains identified as barriers to the full scope of pharmacy practice. Examples of interview questions included: How important is it to you to practice to your full scope? Have you ever had a time when you struggled to find the confidence to use your full scope? A pilot interview was also conducted with two practicing pharmacists and one pharmacy technician to further refine the interview guide.

3.3.2 Step 3: Identifying relevant behaviour change techniques (BCTs)

To identify the BCTs that could be used to target the barriers identified in Step 2, the process outlined by Atkins et al.[125] was followed. A matrix that links each domain to potential BCTs was generated using validated linkages developed by Michie et al.[129] and Cane et al.[134] (see Appendix C). These validated linkages are based on the Behaviour Change Techniques Taxonomy Version 1 (BCT taxonomy v1),[128] which is comprised of 93 non-overlapping BCTs. Next, interview data were used to select BCTs.

3.4 Data analysis

Quantitative data were analyzed using descriptive statistics. Cronbach's alpha was calculated to measure the internal consistency of the survey responses within each TDF domain. Likert items within a TDF domain with an alpha score of less than 0.7 were analyzed individually and not

combined into a single composite score. A median score was calculated for each Likert item to measure central tendency.[135] Likert items with a median score of 3 or above indicated more disagreement with the statement and was therefore identified as a potential barrier.[136] TDF domains with at least one potential barrier were determined relevant. The threshold for significance for all statistical tests was set at $p < 0.05$. Statistical analysis was performed using SPSS version 25 (IBM Corp, New York, USA). To assess non-response bias, demographics of respondents were compared with demographics of the general population, using the *t*-test.[137]

Qualitative data analysis was guided by the Framework Method outlined by Gale et al.,[138] which includes familiarization, coding, indexing, charting, and interpretation of data. A deductive thematic analysis was used to code the transcripts. The domains and associated constructs of the TDF were used as the coding framework.[139] NVivo Qualitative Data Analysis Software version 12 (QSR International, Burlington, MA) was used for coding transcripts. Two researchers (RH and CW) started to code three transcripts independently. An inductive approach was then used to capture any emerging themes within each domain identified. A qualitative researcher (KG) reviewed the coding against the framework. The rest of transcripts were coded independently by RH and CW, and any disagreements were resolved through discussion with KG. Once all data were coded, an Excel spreadsheet was used to generate a matrix that included participant responses with matching codes. Finally, the data was interpreted by reviewing the matrix and exploring connections in participants response to help provide explanations of trends in data and generate themes. All generated themes were reviewed by the research team for agreement. Relevant theoretical domains were identified by consensus discussion between RH and CW. Relevant domains were chosen based on previously published criteria:[140,141] the frequency of beliefs

mentioned, the indication of conflicting beliefs, and the indication of strong beliefs to influence the behaviour investigated. To minimize bias and further validate the finalized themes and related domains, member checking was conducted with three pharmacy professionals (one pharmacist practicing in Ontario, one pharmacist practicing in Alberta, and one pharmacy technician).[142]

Using a deductive approach, quotes were coded independently by two researchers (RH and EL) for the BCTs described by participants when discussing tools and strategies to influence their behaviour. Specifically, data generated from the following questions were used: 1) If we are developing tools for decision-making what do you think would be helpful for you; 2) What strategies helped you overcome challenges and build confidence; and 3) What kind of training would be helpful for you in the future. The research team then reviewed all the identified BCTs and reached consensus on the final list of BCTs, as well determined examples of how to feasibly apply the selected BCTs to computer-based education interventions.

3.5 Results

3.5.1 Substep 1: Survey

3.5.1.1 Survey respondents' demographics

Of the 2696 pharmacy professionals contacted, 225 respondents completed the survey (response rate 8.4%). Not all respondents answered every question. The pharmacy professionals that started but did not complete the survey (n = 68) were excluded from the analysis. Therefore, a total of 225 surveys were analyzed. There were no statistically significant differences between the demographic characteristics of responders and non-responders. The demographics of the

respondents are shown in Table 3-1. Most respondents were female (69.7%), received their training in Canada (78.6%), had more than 10 years of pharmacy practice experience (66.7%), and were practicing in Ontario (74.6%).

The internal consistency of the 11 TDF domains, using Cronbach's alpha (α), ranged from 0.18 to 0.8. Five domains had an alpha value of less than 0.7, which could be related to the small number of items per domain (2-3 items only).

Table 3-1 Demographics of survey respondents (n = 225) and interview respondents (n = 24)

Demographics	Survey N (%)	Interview N (%)
Years of pharmacy practice experience		
Less than 1 year	4 (1.8%)	NA
1-5 years	45 (20.1%)	3 (12.5%)
6-10 years	25 (11.2%)	NA
More than 10 years	150 (66.7%)	21 (87.5%)
Gender		
Woman	157 (69.7%)	21 (87.5%)
Man	58 (25.7%)	3 (12.5%)
Prefer not to disclose	7 (3.1%)	NA
Location of training		
Canada	177 (78.6%)	22 (91.6%)
United States	8 (3.5%)	NA
Outside North America	39 (17.3 %)	2 (8.3%)
Highest level of education		
Bachelor’s degree	130(57.7%)	13 (54.2%)
Entry level PharmD	21 (9.3%)	NA
Master’s degree	11 (4.8%)	3 (12.5%)
Post-graduate PharmD	12 (5.3%)	1 (4.2%)
College diploma	43 (19.1%)	7 (29.2%)
Other	8 (3.5%)	NA
Job title		
Licensed pharmacist	177 (78.6 %)	17 (70.8%)
Licensed pharmacy technician	48 (21.3%)	7 (29.2%)
Primary site of practice		
Community: chain or franchise	91 (40.4%)	11 (45.8%)
Community: independent	64 (28.4%)	4 (16.6%)

Hospital inpatient	44 (19.5%)	6 (25%)
Primary care clinic	6 (2.6%)	2 (8.3%)
Long term care	6 (2.6 %)	3 (12.5%)
Education	5 (2.2 %)	NA
Other	9 (4%)	NA
Province of practice		
Ontario	168 (74.6%)	16 (66.6%)
Alberta	31 (13.7%)	5 (20.8%)
Saskatchewan	5 (2.2%)	NA
British Columbia	4 (1.7%)	1 (4.2%)
Nova Scotia	4 (1.7 %)	1 (4.2%)
Manitoba	4 (1.7 %)	1 (4.2%)
Quebec	3 (1.3 %)	NA
New Brunswick	3 (1.3 %)	NA
Prince Edward Island	1 (0.4%)	NA

3.5.1.2 TDF Domains Analysis

The proportion of pharmacy professionals with positive responses to each Likert item and the median score for each Likert item, along with relevant TDF domains, are shown in Table 3-2. Of the 11 TDF domains, the ones with the highest median scores were ‘environmental context and resources’, ‘beliefs about consequences’, social influences’, ‘memory, attention and decision processes, and ‘emotions’. In particular, increased legal liability and lack of payment for services were the major barriers identified—89% of pharmacy staff agreed that practicing to their scope of practice increased their legal liability, and only 28% agreed they were getting enough payment for their services. On the other hand, domains with the lowest scores were ‘knowledge’, ‘skills’, ‘motivation’, ‘beliefs about capabilities’ and ‘social/professional role and identity’.

Further, while the majority of pharmacists agreed they had adequate skills to perform widely-adopted full scope activities such as adaptation and renewal, only 36% of pharmacists indicated they had practiced independent prescribing or ordered lab tests on most days in the past

three months, and only 26% indicated they had performed point-of-care testing. Additionally, only half of the pharmacists indicated they had adequate skills in ordering lab tests and point-of-care tests, and around two-thirds (68%) indicated they had adequate skills in independent prescribing. Similarly, only two-thirds (68%) of pharmacy technicians indicated they had practiced to their full scope on most days in the past three months despite having sufficient knowledge, skills, and confidence.

Table 3-2 The proportion of pharmacy professionals who agreed and strongly agreed to each statement and medians for each statement with relevant TDF domain

TDF domains	N	Median (IQR)[135]	Strongly agree and somewhat agree (%)
Knowledge			
1. I am aware of the policies and regulations that regulate the full scope of pharmacy practice activities in my jurisdiction	221	1.0(1.0-2.0)	96.38%
2. I know how to perform the following:			
Adaptation of prescriptions	176	1.0(1.0-2.0)	96.5%
Renewal of prescriptions	174	1.0(1.0-1.0)	98.88%
Independent prescribing	174	1.0(1.0-3.0)	65.9%
Administering injections and vaccines	177	1.0(1.0-2.0)	93.08%
Minor and common ailments prescribing	177	1.0(1.0-2.0)	69.8%
Ordering lab tests	177	1.0(1.0-3.0)	50.43%
Point of care testing	177	2.0(2.0-3.0)	54.33%
Independent technician checking of non-sterile compounds**	48	1.0(1.0-1.0)	93.61%
Independent technician checking of prescriptions**	47	1.0(1.0-1.0)	97.91%
Skills (I have the skills to perform)			
I have the skills to perform - Adaptation of prescriptions	175	1.0(1.0-2.0)	94.85%
I have the skills to perform - Renewal of prescriptions	170	1.0(1.0-1.0)	98.23%

I have the skills to perform - Independent prescribing	151	2.0(2.0-3.0)	68.21%
I have the skills to perform - Administering injections and vaccines	160	1.0(1.0-2.0)	85.625%
I have the skills to perform - Minor and common ailments prescribing	147	2.0(1.0-3.0)	73.46%
I have the skills to perform - Ordering lab tests	141	2.0(1.0-4.0)	51.77%
I have the skills to perform - Point of care testing	143	2.0(2.0-4.0)	57.34%
I have the skills to perform -Independent technician checking of non-sterile compounds**	48	1.0(1.0-1.0)	100%
I have the skills to perform - Independent technician checking of prescriptions**	47	1.0(1.0-1.0)	95.74%
In the last three months, when you have a patient who is eligible for the following activities, how often have you provided the following: *(1 = always,2 = most of the time, 3 = about half of the time,4 = sometimes,5 = never, 0=N/A)*			
- Adaptation of prescriptions	176	2.0(1.0-3.0)	69.9%
- Renewal of prescriptions	176	2.0(1.0-2.0)	86.87%
- Independent prescribing	176	1.0(1.0-4.0)	36.08%
- Administering injections and vaccines	176	0.0(0.0-2.0)	78.8%
- Minor and common ailments prescribing	176	0.0(0.0-2.0)	55.17%
- Ordering lab tests	174	0.0(0.0-4.0)	36%
- Point of care testing	173	0.0(0.0-4.0)	26.58%
- Independent technician checking of non-sterile compounds**	47	2.0(1.0-4.0)	61.9%
- Independent technician checking of prescriptions**	44	2.0(1.0-4.0)	65%
Social/Professional Role and Identity [b]			
I believe it is my responsibility as a pharmacy professional to practise to my full scope	222	1.0(1.0-1.0)	95.04%
I believe the following activities are consistent with my professional role as a pharmacy professional:			
Adaptation of prescriptions	176	1.0(1.0-1.0)	98.29%
Renewal of prescriptions	176	1.0(1.0-1.0)	98.29%
Independent prescribing	175	1.0(1.0-2.0)	75.42%
Administering injections and vaccines	175	2.0(1.0-2.0)	82.28%

Minor and common ailments prescribing	176	1.0(1.0-2.0)	92.04%
Ordering lab tests	176	1.0(1.0-2.0)	78.40%
Point of care testing	170	2.0(1.0-2.0)	77.05%
Independent technician checking of non-sterile compounds**	48	1.0(1.0-1.0)	95.8%
Independent technician checking of prescriptions**	46	1.0(1.0-1.0)	91.30%
Beliefs about Consequences [b]			
If I practise to my full scope:			
It may benefit my patients	223	1.0(1.0-1.0)	98.20%
It may harm my relationships with other healthcare providers [a]	222	3.0(2.0-4.0)	37.83%
It may increase my legal liability [a]	223	5.0(4.0-5.0)	89.23%
Beliefs about Capabilities			
I am confident that I can practise the following activities:			
- Adaptation of prescriptions	176	1.0(1.0-2.0)	94.47%
- Renewal of prescriptions	176	1.0(1.0-1.0)	94.43%
- Independent prescribing	175	2.0(1.0-2.0)	73.58%
- Administering injections and vaccines	176	1.0(1.0-2.0)	83.375
- Minor and common ailments prescribing	176	1.0(1.0-2.0)	82.5%
- Ordering lab tests	175	2.0(1.0-3.0)	68.5%
- Point of care testing	176	2.0(1.0-2.0)	70.5%
- Independent technician checking of non-sterile compounds**	47	1.0(1.0-1.0)	97.91%
- Independent technician checking of prescriptions**	47	1.0(1.0-1.0)	93.75%
Motivation and Goals			
I intend to practise to my full scope of practice in the next three months	223	1.0(1.0-2.0)	80.26%
Environmental Context and Resources [b]			
I have sufficient resources - staff/time	221	2.0(2.0-4.0)	54.29%
I have sufficient resources - payment	221	4.0(2.0-5.0)	28.05%
Behavioural Regulation			
I have a clear plan for how to perform the full scope of practice activities	223	2.0(1.0-3.0)	63.22%

Performing full scope of practice activities is something I do automatically (without thinking)	224	2.0(1.0-2.0)	75.89%
Memory, Attention and Decision Processes [b]			
I have tools to guide me on when to implement these activities	223	3.0(2.0-4.0)	47.08%
How often have you forgotten to perform to your full scope of practice? [a] *(1=always, 2=most of the time, 3=about half of the time,4= sometimes, 5= never)*	213	1.0(1.0-2.0)	2.81%
Emotions [b]			
Performing full scope of practice activities make me feel stressed [a]	223	3.0(2.0-4.0)	42.15%
I enjoy performing full scope of practice activities	221	1.0(1.0-2.0)	87.33%
Social Influences [b]			
I feel pressured to practise to my full scope, if I know other pharmacists or technicians are practicing [a]	221	3.0(2.0-4.0)	36.19%
I feel pressured to practise to my full scope, if I have to meet a quota (e.g., a minimum number of flu shots) [a]	223	3.0(3.0-4.0)	47.45%

A median of 3 or above signified a potential barrier to the provision of full scope services.
** full scope services for pharmacy technicians only.
[a] *Statement reverse-coded for data analysis purposes to identify potential barriers.*
[b] *TDF domain with Cronbach's alpha <0.7.*

3.5.2 Substep 2: Semi-Structured Interviews

3.5.2.1 Interviewees' demographics

A total of 72 survey respondents expressed interest in participating in the semi-structured interviews. All were contacted; however, only 24 of the survey respondents agreed to proceed with the telephone interviews. The 24 telephone interviews were conducted between March and April 2020, after which data saturation was reached and no new themes emerged. A total of 17 pharmacists and 7 pharmacy technicians practicing in different clinical settings and provinces were interviewed. The duration of interviews ranged from 20 to 60 minutes. In comparison to survey

participants, more interviewees were women, fewer interviewees were trained internationally, and more interviewees had over 10 years of pharmacy practice experience. However, the demographic differences between participants in the survey and in the interviews were not statistically significant.

3.5.2.2 Identification of relevant theoretical domains

Relevant theoretical domains were identified by consensus discussion between RH and CW. Eight of the 11 domains were determined to be relevant for pharmacists and pharmacy technicians based on previously published criteria (as described above):[140,141] 'social influences', 'environmental context and resources', 'beliefs about consequences', 'social/professional role and identity', 'skills', 'memory, attention and decision processes', 'beliefs about capabilities', and 'behaviour regulation'. The domains 'emotions', 'motivation and goals', and 'knowledge' were not determined to be relevant for pharmacy professionals.

Social Influences

In contrast to the survey, pharmacy professionals in the interviews did not feel that their behaviour was influenced by other pharmacy professionals; in fact, they perceived themselves as role models for their pharmacy colleagues. However, pharmacy professionals listed a number of other individuals who influenced their provision of full scope services, including physicians, managers, and patients. For pharmacists, a key step to adopting full scope services was to establish collaborative relationships with other prescribers, describing the need for *"a collaborator who respects [them] and promotes [their] role"* (RPh 12, NS). In particular, establishing strong

collaborative relationships with neighbouring clinics before providing a new service was key to avoiding conflicts:

> *"I remember when we started giving flu shots, the clinic next door wasn't too happy about that because they lost lots of business, and it was important for us to maintain a good relationship with them. So, we had to back down a little bit the first few years. After a while they just accepted the fact that it's a new era now where pharmacists can do more tasks."* (RPh 24, MB)

In the workplace, managers and employers also substantially influenced full scope services. For example, several pharmacists felt pressured to *"get numbers up"* (RPh 11, AB) in order to meet employer expectations and quotas:

> *"There is a certain amount of pressure from corporate to do certain services. I have a very hard time doing [medication reconciliations] and they're like, 'Why aren't you doing [medication reconciliations]?'"* (RPh 6, ON)

A number of pharmacy technicians also discussed how a lack of support from managers and pharmacists hindered them from fully embracing their expanded role and instead pushed them toward taking on a pharmacy assistant role:

> *"I've probably experienced the opposite, where [managers and pharmacists] have kind of asked me to step down and just go back to a more assistant role."* (Ph.Tech 10, ON)

Environmental Context and Resources

Pharmacy professionals in both the survey and the interviews identified the pharmacy work environment, including staffing and workload, as a major barrier to full scope services.

Pharmacists noted that the workflow led to *"a clash between the dispensing function and the expanded scope function"* (RPh 6, ON), which impeded the implementation of full scope services. Both pharmacists and pharmacy technicians also highlighted that *"retail hasn't evolved yet to [accommodate] the full scope of practice for technicians."* (Ph.Tech 23, ON) . In particular, technicians in retail pharmacy felt that their limited work hours and inadequate payment restricted their role:

> *"There are some technicians who are still not working to full practice… [in] some places you work for two hours of your day and you're paid as a technician and then for the other six hours you're paid as an assistant."* (Ph.Tech 7, ON)

Pharmacists mentioned a number of additional environmental barriers to the provision of full scope services, especially in retail pharmacy. Barriers included limited access to patient medical records, which restricted them to *"only see[ing] a tiny slice of the picture"* (RPh 14, AB), as well as a lack of appropriate communication channels with prescribers. Pharmacists also specifically emphasized the need for *"two-way communication with prescribers, physicians, and nurses to be able to do [full scope services]"* (RPh 13, AB).

Beliefs about Consequences

In addition to the positive consequence of benefiting patients which was highlighted in the survey, interviewees listed other positive outcomes of practicing to their full scope, including promoting collaboration with physicians and easing the burden of the health care system:

> *"Well, I think it [pharmacy professionals practicing to their full scope] lightens the load on the doctors' time in their offices and gives them more time to deal with serious cases or*

> *more complex cases where they have the expertise in. I think for patients, it can provide more effective treatment that can be initiated a lot sooner."* (RPh 16, AB)

In the survey, most pharmacy professionals reported increased legal liability as a result of providing full scope services; however, in the interviews they clarified that they did not perceive this as a negative consequence and instead accepted the increased liability and responsibility for patient outcomes:

> *"Well, I mean, even when we're not the prescriber, we're still liable. When I'm checking a prescription and if it's an inappropriate prescription, I still have a hand in that."* (RPh 4, ON)

Nevertheless, interviewed pharmacy professionals still expressed concern over their full scope of practice and its potential to compromise patient safety, particularly from possible duplications of effort leading to misdiagnoses and treatment errors:

> *"The consequence is misdiagnosis, because we're just doing quick Band-Aid solutions to alleviate immediate discomfort…The physicians don't feel they need to tell us what they're doing for this patient's condition. That could lead to error in treatment and diagnosing, because we could be masking something that the doctor is working on."* (RPh 11, AB)

A number of pharmacists also anticipated that providing full scope services would increase their workload and amplify the complexity of their day-to-day activities, especially when it comes to documentation and follow-up:

"I might get busier with respect to taking care of my patients and being more responsible for follow-up and doing those kinds of professional services, as opposed to the services that we typically provide in a retail pharmacy." (RPh 1, ON)

Social/Professional Role and Identity

While most interviewed pharmacy professionals agreed that full scope services should be part of their professional role, findings of the survey and interviews demonstrated pharmacists' belief that independent prescribing was outside of their duties. Specifically, a number of interviewed pharmacists emphasized that they did not perceive themselves as diagnosticians:

"Very rarely would I do initial prescribing based on a diagnosis, because in my mind we are not diagnosticians." (RPh 9, AB)

While the survey focused on pharmacists and pharmacy technicians' professional role identities, the interviews shed light on their social identities. In particular, interviewed pharmacists highlighted the social identity barriers they faced and how their roles were often unacknowledged by other healthcare professionals, especially by prescribers. Additionally, interviewed pharmacists discussed how their perceived roles differed depending on clinical setting. For example, pharmacists working in clinics and hospitals were not recognized as immunizers because that was part of nurses' role:

"I work in a clinic with lots of nursing staff, and I'm a single pharmacist. When I asked management in the clinic if they wanted me to go and get the full scope to do some injections, they said that they would prefer that I work to my scope regarding drugs and they let the nursing staff do the rest." (RPh 9, AB)

Pharmacy professionals also highlighted unclear role definitions and blurred professional boundaries as barriers to their provision of full scope services. In particular, pharmacy technicians mentioned that their overlapping professional responsibilities with pharmacists posed a challenge to working with more experienced pharmacists who still considered dispensing as part of their role:

> *"There have been some older pharmacists who are not too comfortable with giving those responsibilities to technicians yet. I guess it's their mindset and their training—they've been doing things the way they have been doing for so long that it's just hard for them to let go of those tasks."* (Ph.Tech 21, ON)

Technicians also felt that the issue of blurred professional boundaries was not limited to pharmacists and that prescribers and the public also do not perceive technicians as regulated professionals, but rather as unregulated assistants:

> *"Some of the prescribers, I don't think they understand what a pharmacy technician can actually do. So, they're just used to say, 'Can I speak with the pharmacist?' 'Well, you could give me that prescription.' 'Well no, I need to speak with a pharmacist.'"* (Ph.Tech 23, ON)

> *"Public awareness as well, like people coming into the pharmacy, they just think the person in the lab coat is a pharmacist and they only can speak to them. They don't realize a pharmacy technician can give them the product demonstration."* (Ph.Tech 21, ON)

Skills

Interviewed pharmacists discussed several training courses that successfully enhanced their ability to provide full scope services. However, a number of pharmacy professionals denied receiving any formal training in full scope activities and indicated their skills were acquired through either self-study or on-the-job practice. These responses were consistent with survey findings for pharmacists, which indicated that their lack of skills in independent prescribing and ordering lab tests could be attributable to inadequate training:

> *"As far as training, I didn't get any formal training. It was just word of mouth**.** I looked at what the Alberta College of Pharmacy required."* (RPh 9, AB)

A number of pharmacists also discussed how pharmacy programs have changed to increase the amount of education and training pharmacy students received in full scope services, leading to practice differences between newer pharmacy graduates and more experienced pharmacists:

> *"I am an older [pharmacist] in the profession. So I find that newer grads coming out of, for example, Waterloo or Toronto, a lot of their stuff [training] is based on the newer stuff [practice changes] that's going to be happening. I've had no exposure to it whatsoever."* (RPh 22, ON)

Memory, Attention and Decision Processes

The majority of interviewed pharmacy professionals indicated they were generally able to remember the regulations and criteria for providing full scope services, which echoes findings of the survey. However, a number of interviewed pharmacists expressed difficulty remembering criteria that was unclear, recently changed, or new:

> *"It's when we get a whole bunch of stuff all at once, sometimes it's a bit of a challenge to remember, not only what you can do but how to do it, and how to bill for it, what are the parameters within."* (RPh 17, ON)

A number of pharmacists also discussed the impact of distractions due to workload and limited staffing on their ability to maintain enough attention to carry out expanded scope services:

> *"So, say for physicians, they have a quiet time in front of them [with] just the patient. They don't answer the phones, they don't get the till. They don't have people coming in [saying], "Oh I need my injection now." There's so many distractions, that it's hard to focus on the idea of quality full scope"* (RPh 14, AB)

Additionally, insufficient decision-making tools were highlighted by pharmacy professionals in both the survey and the interviews. In particular, interviewed pharmacy professionals indicated that the current resources and tools are scattered and difficult to locate. They also expressed the need for a comprehensive and accessible full scope application to be able to provide quality care to their patients:

> *"It would be really nice to have a comprehensive education platform for Expanded Scope. We get it piecemeal, a little bit here and a little bit there. But if we could have one place where we could go to that has everything concise and all of our questions answered, without having to dig."* (RPh 6, ON)

Beliefs about Capabilities

While pharmacy professionals in the survey indicated having satisfactory levels of self-confidence in delivering most full scope services, interviewed pharmacy professionals highlighted a number

of situations in which they felt less confident in their capabilities. For example, both pharmacists and pharmacy technicians reported struggling with having confidence in their abilities when providing a full scope service for the first time:

> *"Yeah, all the time, especially when something is new. You definitely struggle with confidence. Well, for example, when we started vaccinating, the first time I did a Gardasil I was like, 'Oh my goodness. How am I going to do this?'"* (RPh 6, ON)

Interviewed pharmacists also discussed lacking confidence in their ability to make judgements for complicated cases, or to make decisions with limited information about their patients. They also expressed their need to *"refer [complex] patients back to their specialist"* (RPh 11, AB):

> *"I'm not comfortable in patients who are very complex where there's multiple specialist players in the patient… with complex patients I'm less likely to go at on my own. Single disease state, and especially things where my decisions are not putting a patient at risk. I've got no problems. But if the decision that's made is something that could have a lot of drug interactions, No, I'm not so comfortable."* (RPh 9, AB)

Some pharmacists also felt less confident when other providers did not support their role, fearing that providing full scope services would harm their relationship with these providers:

> *"We've had a particular physician who has been a little bit territorial, I would say, with his patients… I certainly feel less confident with those particular patients for that particular physician to go to my full scope, even if it's something that is appropriate, because I'll find I'll get some pushback."* (RPh 13, AB)

Behaviour Regulation

The ‘behavioural regulation’ domain refers to any action or measure taken to encourage the implementation of the desired behaviour. Although survey findings highlighted that pharmacy professionals generally lacked adequate planning, interviewed pharmacy professionals discussed a number of preparatory steps that were deemed essential for the provision full scope services. In particular, additional training courses, the availability of resources, regulatory support, and reimbursement were all perceived as necessary:

> *“I would look, first of all, do I have the skills and the knowledge? And if I don't, do I have the ability and the background knowledge to learn how to do it? And then making sure I have the correct resources to be able to learn about it. The next thing would be figuring out the parameters and the regulations within how we do it and who we can do it with. And then thirdly, I guess, reimbursement or is it worth my while? Are we going to be paid for this?”* (RPh 17, ON)

Interviewed pharmacists also stressed the importance of receiving additional certification and advanced training before providing certain full scope services, such as independent prescribing and ordering lab tests:

> *“I think we would need much more training for sure. I mean the adaptation and the prescription renewals; we're sort of doing that anyway. But [newer scope services like independent prescribing or ordering lab tests are] uncharted territory. There would have to be some courses to take.”* (RPh 6, ON)

3.5.3 Step 3: Mapping of theoretical domains to BCTs

A total of 18 BCTs were identified. BCTs, their respective TDF domains, and their potential applications to computer-based interventions are shown in Table 3-3 All identified BCTs were suggested by or discussed with the interviewed pharmacy professionals, except for ‘action

planning' which was selected based on the quantitative analysis. The quotations for each BCT and their mapped TDF domains are shown in Appendix D. Not all of the identified BCTs were applicable to computer-based interventions; restructuring the physical pharmacy environment is an example of such a BCT. Therefore, the 'environmental context and resources' domain and its constituent BCTs (restructuring the physical environment, restructuring the social environment) were not reported in Table 3-3.

Table 3-3 Proposed behaviour change techniques (BCTs*) with relevant TDF domain(s) and application of the identified BCTs to computer-based intervention(s)

Proposed BCT [134]	TDF domain(s)	Application of BCT to computer-based intervention(s)
Demonstration of the behaviour by others / modeling	Skills/ Social influence	• Videos showing other pharmacists/pharmacy technicians demonstrating a full scope activity
Behavioural rehearsal/practice	Skills/ Beliefs about capability	• Case-based quizzes to practice certain clinical or technical skills • Computer simulations to rehearse the provision of full scope services
Graded tasks	Skills/ Beliefs about capability	• Quizzes with increasing levels of difficulty or complexity
Instruction on how to perform a behaviour	Skills	• Videos/infographics showing systematic steps on how to perform full scope services, including greyscale print-out versions
Increasing skills: problem solving, decision making, goal setting	Skills	• Interactive decision-making clinical scenarios with the resulting consequences [a] • Modules incorporating decision-making tools (e.g., decision trees, algorithms)

Credible source	Beliefs about capability	• Videos showing an expert or leader in the field presenting arguments in favour of performing full scope services
Prompts and cues	Memory, attention and decision processes	• Modules incorporating data visualization tools to display content (e.g., bullet points of clinical practice tips) • Modules incorporating cheat sheets or checklists for quick reference
Action planning	Memory, attention and decision processes/ Behaviour regulation	• Modules guiding explicit planning/downloadable templates for planning of the provision of full scope services
Self-monitoring of behaviour	Memory, attention and decision processes/ Behaviour regulation	• In-platform self-reflection (e.g., to provide self-feedback regarding full scope services) • Downloadable templates to monitor and record daily activities related to full scope of practice
Identification of self as role model	Social influence	• Videos sharing how users' behaviour set examples for other pharmacy professionals
Social comparison**	Social influence	• Virtual sessions for users from different provinces to connect and ask questions (e.g., through video conferencing or a message board) • Videos/quizzes providing information on what/how pharmacy professionals from different provinces adopt full scope services
Information about others' approval	Social influence	• Videos showing other healthcare professionals presenting arguments in favour of pharmacy professionals performing full scope services
Social reward	Social influence	• Reward systems (verbal or non-verbal reward) allowing users to feel gratified for their effort/progress in performing full scope services
Social support or encouragement	Social influence/ Professional role and identity	• Virtual sessions for users from different provinces to connect and ask questions (e.g., video conferences, message boards)

Salience of consequences**	Beliefs about consequences	• Videos emphasizing the consequences of providing full scope services • Interactive decision-making clinical scenarios with the resulting consequences [a]
Information about social and environmental consequences	Beliefs about consequences	• Videos providing information about the social and environmental consequences of providing full scope services
Comparative imagining of future outcomes**	Beliefs about consequences	• Interactive decision-making clinical scenarios with the resulting consequences [a]
Vicarious consequences**	Beliefs about consequences	• Videos emphasizing the consequences of providing full scope services

*BCT is defined as "an observable component of an intervention designed to alter or redirect causal processes that regulate behaviour".[143]

**Definitions of the BCTs as per the BCT Taxonomy (v1)[143]: Social comparison: Draw attention to others' performance to allow comparison with the person's own performance; Salience of Consequences: Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences); Comparative imagining of future outcomes: Prompt or advise the imagining and comparing of future outcomes of changed versus unchanged behaviour; Vicarious consequences: Prompt observation of the consequences (including rewards and punishments) for others when they perform the behaviour.

[a] Interactive decision-making clinical scenarios: to train users on how to rationalize decisions with complex cases or with limited information and to improve thought and critical thinking processes.

3.6 Discussion

In this mixed method study, we used the TDF to identify barriers and facilitators to pharmacists and pharmacy technicians' uptake of full scope services in Canada. In the survey, a lack of sufficient resources was the major barrier to practicing to full scope, whereas in the interviews, social influences were the most frequently discussed. The use of the TDF theoretical lens in this study helped uncover additional barriers absent from the literature, including a lack of professional collaboration, incomplete professional identity, and challenges with decision-making. Based on this, we identified 18 BCTs that could be easily implemented in computer-based education to support the adoption of full scope services, such as modelling through videos, social support, and

encouragement through peer connections. Previous studies have also shown that multi-component interventions are more efficient than single-component interventions in influencing clinical behaviours, suggesting that multiple BCTs could be combined.[144-147]

One of our key findings was the marked impact of a pharmacy professional's social network, including the pharmacy team and other prescribers, on the uptake of full scope services. Similar to existing research,[148] pharmacists consistently expressed a need to gain prescribers' approval before practicing to their full scope to avoid conflicts. Furthermore, pharmacists felt less confident adapting or initiating prescriptions for unsupportive prescribers.[111] Technicians reported similar influences, but from their pharmacy team rather than from other prescribers. In particular, there were examples of pharmacists and managers who did not support the technician role. This could escalate conflicts among members of the pharmacy team and create a demotivating work environment that could ultimately impact patient care.[149] This also signals a gap in interprofessional and intra-professional collaboration skills among pharmacy professionals which are crucial for practice change,[150] and key areas of improvement for continuing professional development. Several pharmacy professionals mentioned the positive impact of group learning and experience sharing on their collaboration with other professionals. Therefore, collaborative team-based interventions allowing pharmacy professionals to connect and share experiences with other supportive healthcare professionals (e.g., videoconferencing) could also influence practice change.[147]

Our study also showed that current pharmacy environments and workflows hamper practice change, which is in agreement with previous studies.[126,127] Notably, we observed that organizations imposed their authority to limit technicians' role by restricting employment

opportunities and working hours. Technicians cited examples of getting paid as technicians for a few hours per day and as assistants for the rest of the day. This limited the ability of registered technicians to free up pharmacists' time. As such, an organizational approach is needed to modify the current payment model for pharmacy technicians. Furthermore, pharmacy professionals felt that current healthcare infrastructure would not support full scope services due to a lack of access to patient information, inefficient communication channels with prescribers, and increased workloads.[111,151] This indicates that environmental changes (e.g., pharmacist-prescriber secured messaging applications, accessible electronic patient records) could facilitate practice change.

Our study also suggested that pharmacists need to embrace a professional identity as independent clinicians to accelerate the evolution of pharmacy practice. This finding is consistent with results of previous studies.[152-155] Of the pharmacists interviewed who have the training and authority to prescribe, most did not see prescribing as part of their professional role. This can be anticipated as a future barrier among pharmacists practicing in jurisdictions where they do not have the authority to prescribe yet. New pharmacy graduates who are still developing their professional identity may face additional struggles when exposed to pharmacists adopting a dispensing-professional identity.[151,156] Furthermore, this could impinge on the integration of pharmacy technicians into pharmacy workflow.[157] Kellar et al.[153] hypothesized that if pharmacists do not adopt a clinician professional identity, no amount of changes in legislation, reimbursement, or advanced training will be enough to facilitate a change in practice. As such, computer-based interventions can build a stronger professional identity through connecting pharmacy professionals with outstanding mentors and positive role models to provide support and encouragement.[151,156,158]

Findings from this study were in line with recent research examining pharmacists' lack of confidence with complex decision-making.[117,158,159] Pharmacists cited examples for how training usually focuses on simple, straightforward cases rather than complex ones. Pharmacy professionals also highlighted a lack of sufficient decision-support tools to guide them in their practice settings, particularly with complex, ambiguous situations. While resources are available, retrieving updated information while working in a fast-paced work environment is difficult. A 2014 systematic review[160] of medical staff using digital decision-making tools found that clinicians who had access to these tools made safer and more appropriate diagnostic decisions as the delivery of appropriate care became more complex. Efforts must be made to support pharmacy professionals in building confidence when making decisions in ambiguous cases as part of their full scope.[159] As such, computer-based interventions could use both typical simple cases and complex cases to sharpen pharmacy professionals' decision-making and problem-solving skills.[117] Furthermore, developing decision-support tools that are concise yet comprehensive could improve their clinical decision-making and uptake of full scope services.[160]

There are a number of limitations for this study. First, the low response rate for the survey should be noted (8.4%), although this rate is in line with previously-reported survey response rates of pharmacists in Nova Scotia (8%).[127] Despite the low response rate, participants in the survey reflect diversity in years of experience, primary site of practice, and province of practice. Moreover, the triangulation of the quantitative data with the qualitative data helped strengthen the generalizability and validity of the results. Another limitation is the social desirability bias with the survey responses, which could have resulted from the nature of questions, in particular the confidence and memory-based questions. The low Cronbach's alpha for certain TDF domains

indicates that results should be interpreted with caution. This could have been addressed by using a minimum of three statements per domain. Limitations of the qualitative interview phase of the study are the relatively small number of pharmacy professionals involved and the fact that a high proportion (87%) of the recruited participants had more than 10 years of experience. The study could have been strengthened by recruiting more recently-graduated pharmacy professionals to allow for a comparison in perceived barriers and facilitators to practice change. One important challenge with coding statements using the TDF domains was the overlapping nature of the domains, the absence of standardized domain definitions, and the lack of illustrative examples of how to operationalize domains with data coding.[161] Another challenge was with selecting BCTs. The mapping work of Michie at al.[129] and Cane et al.[134] was used to obtain a more comprehensive list of BCTs, but some domains such as 'professional role/identity' and 'behaviour regulation' had a limited number of BCTs. Additionally, although our participants discussed BCTs such as "Identification of self as role model" and "Valued self-identity" for the 'professional role/identity' domain, these BCTs were omitted due to lack of consensus in literature.

3.7 Conclusion

Using the TDF approach, this mixed method study identified unique factors distinct from commonly-reported barriers such as a lack of skills, confidence, time, and staffing. As the study included pharmacists and pharmacy technicians from across Canada where scope differs by jurisdiction, the findings showed that enabling regulations alone are not enough to facilitate practice change. Other factors such as professional identity, decision-making skills, increased liability, and social networking are equally important. There is also a need to restructure current

pharmacy infrastructure to accommodate full scope services, including the addition of efficient communication channels with prescribers and the implementation of adjusted payment models for pharmacy technicians. This study identified a number of behaviour change techniques that can be incorporated into educational platforms to enable practice, modeling, and peer support and encouragement, thereby building confidence and facilitating practice change.

3.8 Competing interests

The authors declare that they have no competing interests.

3.9 Authors' contributions

RH developed the survey and the interview guide, conducted the interviews, analyzed the data, and led the writing of the paper. CW contributed to the design of the study, analyzed the interviews data, reviewed results, and contributed to the writing of the manuscript. EL contributed to the design of the study, analyzed the interviews data, reviewed results, and contributed to the writing of the manuscript. KG contributed to the design of the study, critiqued the survey and the interview topic guide, and contributed to review of results and writing of the manuscript. All authors reviewed various drafts of the manuscript and approved the final manuscript.

3.10 Declaration of competing interest

The authors declare that they have no competing interests

Additional context

In this thesis, the overall goal of this theory-based study was to assess the barriers and facilitators of full scope services to guide the design of future Pharmacy5in5 modules about full scope services. Moreover, the study aimed to identify optimal behaviour change techniques that are applicable to the Pharmacy5in5 platform. As such, it was crucial to use a comprehensive framework to identify all possible barriers and facilitators for full scope services and corresponding behaviour change techniques. It would have been challenging to base the intervention on a certain theory without limiting the risk of missing other relevant theories, or selecting irrelevant ones. For example, the theory of planned behaviour would address subjective norms, perceived behavioural control and attitude.[162] However, this theory does not take into consideration emotions evoked by the full scope services. On the other hand, emotions such as fear, anxiety, burn out and stress are addressed under the TDF domain "emotions". As such, using TDF was the most appropriate framework to use for this study as it is a comprehensive framework that combines a total of 33 behaviour change theories.

While the most of TDF-based studies have used a qualitative approach,[130,133,163] this study has adopted a mixed method approach to provide an in-depth understating of the pharmacy professionals ' provision of full scope services. The study highlighted the value of using mixed methods to enhance the validity of findings. For example, the quantitative data supported the qualitative data to identify high frequency domains. Moreover, the quantitative data helped identify important domains that were infrequently discussed in the qualitative data such as behaviour regulation and action planning.

In terms of the study population, the study included both pharmacists and pharmacy technicians. The scope of pharmacy technicians in Canada includes, but is not limited to,

independent prescription compounding and independent prescription checking for technical accuracy.[164] Overall, pharmacy technicians play a key role in supporting pharmacists to practice to their full scope. In particular, pharmacy technicians can take up the dispensing function in pharmacies which frees up pharmacists' time to focus on full scope services rather than providing full scope services on top of their regular workload.[165] Moreover, including multiple perspectives from pharmacists and pharmacy technicians provided a fuller picture of the barriers and facilitators of full scope services.

Chapter 4

Evaluating the effectiveness of the computer-based education platform, Pharmacy5in5, on pharmacists' knowledge of anticholinergic toxicity using a randomized controlled trial

This chapter is published as follows:

Hussein R, He Z, Bareham J, Patel T, Killeen R, Grindrod K. Evaluating the Effectiveness of the Computer-Based Education Platform, Pharmacy5in5, on Pharmacists' Knowledge of Anticholinergic Toxicity Using a Randomized Controlled Trial. Pharmacy. 2022; 10(1):8. https://doi.org/10.3390/pharmacy10010008

4.1 Overview

Background Computer-based education has been widely implemented in healthcare professional development education. However, there has been little examination of the potential for computer-based education to enhance pharmacists' knowledge. This study aims to assess the effectiveness of computer-based education on improving pharmacists' knowledge compared to printed education material.

Methods This study was a web-based randomized controlled trial. Participants were randomly allocated to either an intervention group where they had access to the computer-based education module on Pharmacy5in5.ca or to a control group where they had access to printed educational material. Knowledge gain was assessed using a pre- and post-knowledge test.

Results A total of 120 pharmacists were recruited and 101 completed the post-knowledge test (50/60 in the intervention group; 51/60 in the control group). Both groups showed a significant increase in knowledge gain (intervention group: pre-test mean score 19.35 ± 3.56, post-test mean score 22.42 ± 3.812, p value < 0.001; control group pre-test mean score 19.22 ± 3.45, post-test mean score 23.29 ± 3.087, p value < 0.001). However, the difference in knowledge change was not significant between the two groups (22.42 vs. 23.29, p value = 0.333).

Conclusions In this study, a computer-based education module enhanced pharmacists' knowledge to a similar degree to printed education material. Efforts should be made to provide computer-based education as an option to support pharmacists' professional development.

Keywords*: computer-based education; knowledge; anticholinergic toxicity; pharmacists; education; distance*

4.2 Introduction

Many commonly prescribed and over-the-counter medications such as antihistamines and tricyclic antidepressants have anticholinergic properties, contributing to a wide range of side effects such as dry mouth, delirium, and urinary retention.[166] The aging population, which is growing in Canada, is particularly vulnerable to these side effects due to comorbidities, polypharmacy and potential drug–drug interactions.[167-169] Using one anticholinergic medication may result in problematic side effects, but using multiple anticholinergic medications can create a cumulative anticholinergic burden leading to anticholinergic toxicity.[170,171] Further, a 2015 systematic review by Salahudeen et al.[172] highlighted that a higher anticholinergic burden leads to a decline in cognitive ability and physical function among older adults. Moreover, anticholinergic toxicity can lead to emergency department admissions.[169,170]

Pharmacists, as highly accessible healthcare professionals, are in an ideal position to identify patients at high risk of developing anticholinergic toxicity, and to provide or recommend safer alternatives to reduce anticholinergic burden. In particular, patients' easy access to over-the-counter medications with anticholinergic properties, as well as, the high prevalence of inappropriate use of anticholinergic medications,[168] makes it important for pharmacists to review anticholinergic burden in their patients. Moreover, pharmacies often have the most comprehensive medication lists of all the healthcare organizations, especially for patients that use a single pharmacy for all of their medication needs. This permits pharmacists to comprehensively examine the anticholinergic burden their patients may be exposed to through the use of both prescription and non-prescription drug use. A 2020 systematic review by Nakham et al. found that medication reviews conducted by pharmacists decreased anticholinergic burden effectively.[173] Given the

significant role of pharmacists in optimizing anticholinergic medication use,[173-175] it is necessary to provide adequate training and support in this area.

Different types of educational interventions are available for professional development for pharmacists. For example, passive interventions such as printed educational material are commonly used.[176] A study by Kouladjian et al.[177] reported that journal articles are appropriate for educating pharmacists on estimating drug burden index, a measure of the total exposure to medications with anticholinergic and sedative properties. However, pharmacists may prefer more active interventions such as computer-based education.[18,34,178] Compared to printed material, computer-based education can increase convenience by delivering content at any time and from anywhere, while allowing self-paced learning. Moreover, it increases users' interactivity and engagement with the material.[66,67]

The ability of computer-based learning to improve knowledge has been well established for nurses and physicians, however, there is limited evidence evaluating its use among pharmacists.[89,179] Moreover, most studies targeting pharmacists focus on pharmacy students rather than experienced pharmacists.[180-183] Furthermore, there is limited research assessing pharmacists' knowledge on anticholinergic toxicity using a computer-based educational platform. Hence, the aim of this study is to assess the effect of a computer-based educational platform, Pharmacy5in5, on pharmacists' knowledge of anticholinergic toxicity compared to using standard printed educational material.

4.3 Methods

4.3.1 Study Design

A two-arm, parallel web-based randomized controlled trial (RCT) was used to assess the effectiveness of the Pharmacy5in5.ca platform on pharmacists' knowledge. Ethics approval for this study was obtained from the University of Waterloo Ethics Committee (ORE # 42710). The RCT was conducted in accordance with CONSORT-EHEALTH checklist.[184] Participants were randomly allocated to the intervention group or the control group as shown in the study flowchart below (Figure 4-1).

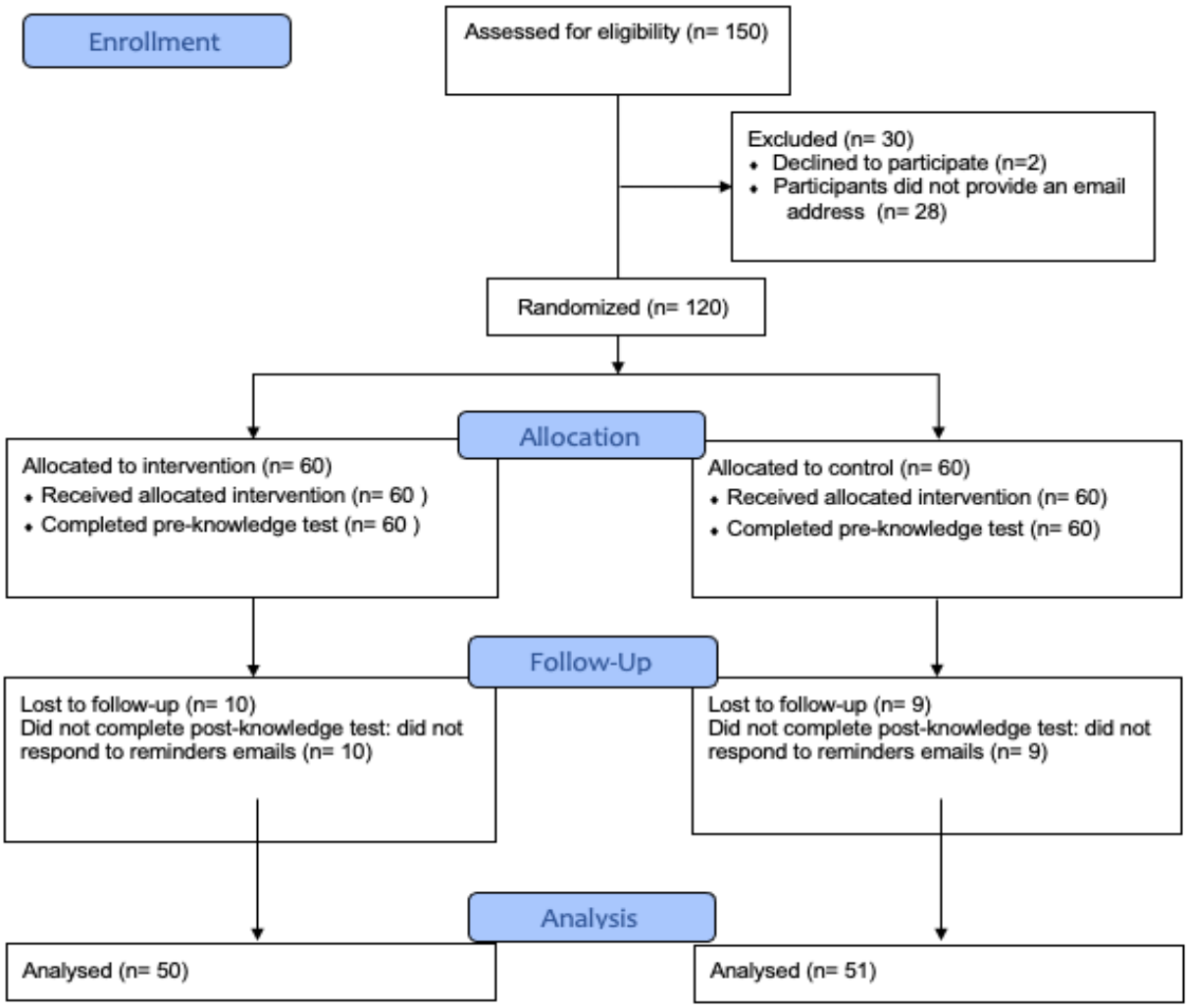

Figure 4-1 Study flowchart

4.3.2 Recruitment

All registered users of Pharmacy5in5.ca in Ontario (*n* = 9314) were invited to participate in the study via email. In the email, users received a consent form and a link to a survey to screen for eligibility according to inclusion/exclusion criteria. For this study, inclusion criteria included being

a registered user of the Pharmacy5in5. platform and a licensed or registered pharmacist practicing in the province of Ontario, Canada. Exclusion criteria included Pharmacy5in5.ca registered users who were pharmacy technicians, pharmacy students, pharmacy technician students, or unlicensed pharmacists. A total of three recruitment emails were sent to increase response rate.[131,185]

4.3.3 Study Procedure

All potential participants were asked via email to complete an online 26-question pre-test and demographic survey. Participants who completed the baseline assessment were assigned a unique study identifier and randomly allocated to one of the two study arms. Participants allocated to the intervention group were sent a second email with a link to the Pharmacy5in5 platform, with access granted to an *Anticholinergic Toxicity* module. Participants were given one week to complete the one-hour *Anticholinergic Toxicity* module on Pharmacy5in5.ca. This module was designed specifically for this trial and had not been released to other platform users (only users enrolled in the intervention arm had access to this new module to reduce the risk of contamination[186]). Users had the freedom to access all module components in any order they chose. No additional content development or refinement was performed on the platform or modules while conducting the trial. The intervention group had continuous access to the Pharmacy5in5 platform, which is available on computers, tablets, and smartphones. Given that recruited users were already registered users of the Pharmacy5in5 platform, no training was provided before or during the intervention on how to use the platform. Participants allocated to the control group were instructed via a second email to review printed education material, which included a paper-based decision aid, over the same one-week time frame.

After one week of accessing the Pharmacy5in5.ca module or the print education material, all participants were invited to complete a post-test via email. In the email, participants in the intervention group were asked to complete the module quizzes before taking the post-test. The post-test quiz included the same questions as the pre-test, but in a different order to assess knowledge gain. To access the post-test quiz, participants were asked to enter their study ID and were instructed to answer the questions to the best of their ability and not to consult other materials while taking the quiz. Throughout the study, up to four reminder emails were sent to prompt participants to complete the post-knowledge test.

4.3.4 Interventions

4.3.4.1 Computer-Based Educational Platform

Pharmacy5in5 is a computer-based education intervention that is freely available to all pharmacy professionals in Canada. The platform aims to accelerate the adoption of best practices by pharmacy professionals. On registration, users provide their demographic information along with consent to use their non-identified data for research purposes. The platform was developed through three cycles of user testing with pharmacists, pharmacy technicians, and students, where users were asked to interact with the platform while explaining their impressions, actions, and any areas of confusion. Users also completed the Systems Usability Scale (SUS) as a validated measure of usability.

Pharmacy5in5 is designed to regularly release modules that cover five take home messages about a clinical or pharmacy practice topic. Each module is created by a team of experts to provide real-world examples of how evidence, guidelines and practice tools can be used in daily practice.

The platform also provides much needed information about trending topics. For example, in the recent "COVID-19" module, users were provided with latest evidence regarding the use of COVID-19 vaccines during pregnancy and breastfeeding. Each module has the following design components: One fast facts quiz with immediate feedback; six case-based quizzes, with delayed feedback;[120] peer comparison; self-reflection questions to self-report behaviours; and multimedia resources

- Quizzes: each module consists of one "Fast Facts quiz" and six "Case-based quizzes" that are based on the module learning objectives. The "Fast Fact quiz" tests users' basic knowledge about the clinical topic, while "Case-based quizzes" test users' knowledge and behaviour through helping a fictional pharmacist make the optimal decision in cases based on real-life scenarios. Questions used are multiple choice or true/false.
- Feedback: in each module, online quizzes are followed with feedback on users' performance. Each "Fast Fact quiz" provides users with immediate feedback after each question to let them know if they got the right answer. "Case-based quizzes" provide delayed feedback after the user finishes the whole quiz series, along with the correct answer, rationale, and links to useful resources underneath each question.
- Peer comparison: this feature aims to compare a user's performance to an average user and provides feedback on user progress. Peer comparison also rewards users who outperform an average user, and motivates users who perform below average.

- Self-reflection: after each case-based quiz, users are asked to answer a question about their past behaviour. Self-reflection questions are structured as follows: “in the past 3 months have you/did you…”. This feature allows users to self-report their behaviours, which can help detect any changes in users’ behaviour before and after taking the module.
- Multimedia resources: there is a set of specific resources created for each module, including: flashcards, infographics, and short videos. These multimedia resources highlight the key take home message for each clinical topic and can be shared on social media.

The platform was designed using a combination of the Theoretical Domains Framework (TDF), the COM-B (capability, opportunity, motivation, and behaviour) model, and the Behaviour Change Wheel (BCW), to understand factors that influence pharmacist behaviour. The TDF includes 14 domains for potential determinants of behaviour (e.g., knowledge, skills, beliefs about capabilities, etc).[120] The COM-B model demonstrates how an individual’s *capability*, *opportunity*, and *motivation* impact *behaviour*, and can be linked back to specific TDF domains.[139] Based on the COM-B, Pharmacy5in5 aims to change pharmacist behaviour by targeting pharmacist *capability*. This corresponds to TDF behaviour change domains such as *knowledge, skills, decision processes*, and *behavioral regulation*.[139] The BCW shows how the COM-B domains can be targeted by a variety of behavioural interventions and policies.[187] Pharmacy5in5 uses three behavioural interventions, including *modelling* (learning through imitation), *education* (gaining knowledge), and *training* (gaining skills).

4.3.4.2 Printed Materials

The printed education material used for this study was provided as an 11 pager PDF document and included two references: (1) RxFiles: Reference List of Drugs with Potential Anticholinergic Effects which is a paper-based decision aid;[188] and (2) Anticholinergic Toxicity review by Broderick et al., 2020.[170] These two references were used in the development of the Pharmacy5in5 online module content. The RxFiles drug charts are unique decision aids used by Canadian pharmacists and physicians in practice. The charts provide evidence-based information about drugs to help providers make therapy decisions.[189]

4.3.5 Anticholinergic Toxicity Module Development and Validation

To create the *Anticholinergic Toxicity* module, the Pharmacy5in5 content developers started by drafting learning objectives (Box 1). Next, the learning objectives were used to develop two educational infographics (Figure 4-2), one short animated video (1:06 min long), and five flash cards (Figure 4-3). The content developers also developed an introductory immediate feedback quiz and six case-based delayed feedback quizzes to address the learning objectives. Next, all the module components were reviewed through two rounds with a panel of three experts. In the first round, the content of the module was shared with the panel via email to gather comments and critiques for each question and all multimedia resources, and modifications were made accordingly. A total of seventeen questions were modified and the two infographics were clarified based on expert feedback. For the second round, the full module was shared after modifications and 12 questions were reworded slightly as per expert feedback. Before launching the study, the

module was piloted with five practicing pharmacists to assess any concerns with readability and clarity of wording.

Box 1. *Anticholinergic Toxicity* module learning objectives.

1. Recognize anticholinergic side effects when assessing patients, including anticholinergic toxicity.
2. Identify higher risk anticholinergic drugs, including additive effects.
3. Classify patients according to their risk for serious anticholinergic side effects.
4. Identify safer alternatives for indications where anticholinergic drugs are commonly used.
5. Implement a plan to switch an anticholinergic drug to a safer alternative, deprescribing, tapering, switching, and incorporating washout periods.

.

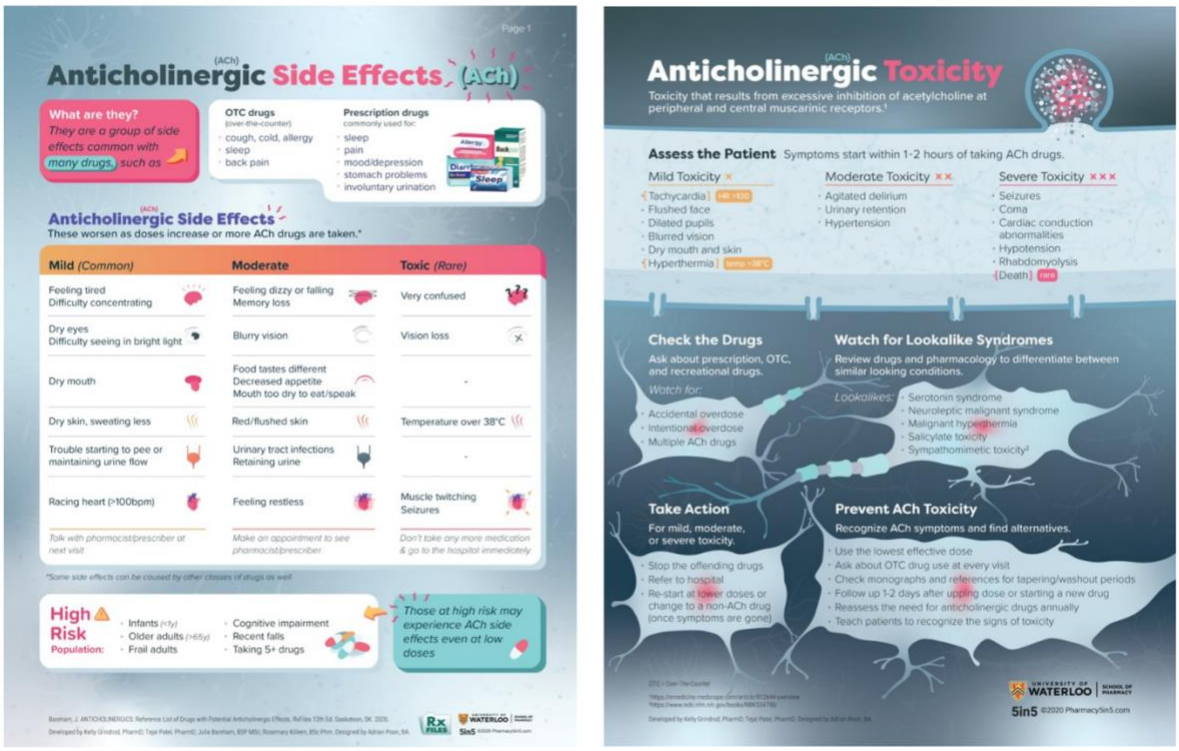

Figure 4-2 Anticholinergic toxicity module educational infographics

Figure 4-3 Anticholinergic toxicity module flashcards

4.3.6 Outcome Measure

The main outcome measure was the difference in the post-test quiz score between the intervention and control group using pre-post validated knowledge tests. A secondary outcome measure was the change in the intervention group's and control group's quiz scores, before and after the intervention.

4.3.7 Sample Size Calculation

With a power of 80% and a two-tailed alpha of 0.05, an estimated 45 users were needed for each group to show a 5% difference in knowledge between the two arms post-test scores (standard deviation 1.23 based on a previous pilot study, 2-sided test, $p < 0.05$, power of 80%). Taking into consideration the high dropout rate with internet-based interventions,[37,184] we enrolled 120 participants to account for an expected 25% dropout rate.

4.3.8 Randomization and Blinding

After enrollment, eligible participants were randomised using a 1:1 allocation ratio via a computer-generated random number by an independent research member who was not involved in the data analysis. Given the nature of the study, it was not feasible to blind the participants. However, only

the primary investigator was aware of the allocations. The study team was blinded to allocation until the analysis was completed.

4.3.9 Data Analysis

Average scores were computed for the primary outcome (knowledge score out of 29) and reported as mean ± SD. The normality of pre- and post-knowledge test scores were tested using Kolmogorov–Smirnov and Shapiro–Wilk test. As the data was found to be skewed, nonparametric tests were used to compare the outcomes between the control and intervention groups using Mann–Whitney U test and Wilcoxon Signed ranks tests to compare within groups at before and after the intervention.[89] Additional analyses included assessing differences in baseline sociodemographic factors between the control and intervention groups, and between respondents and non-respondents using Chi-square and Fisher's exact test. $p < 0.05$ was considered statistically significant. Statistical analysis was performed using SPSS version 27 statistical package (IBM Corp, New York, NY, USA).[190]

4.3.10 Knowledge Test Development and Validation

4.3.10.1 Knowledge Test Development

To assess if the use of the platform results in knowledge gain, a knowledge test was developed as outlined by Case and Swanson.[191] The first draft of knowledge test included a total of 33 questions that were developed based on the module learning objectives. The knowledge test questions were different from the questions in the module quizzes and included a combination of clinical vignette questions and standard questions. The questions were constructed to address Blooms' Taxonomy

lower and higher order thinking levels. First, the knowledge test was reviewed by two senior content developers who were asked to code each question to the corresponding learning objective and Bloom's level to ensure that there were at least three questions addressing each learning objective as well as an equal number of questions assessing Bloom's Taxonomy lower and higher order thinking levels.

4.3.10.2 Knowledge Test Validation

The knowledge test was validated with geriatric pharmacotherapy experts in two rounds. In the first round, the experts were asked to rate each question in terms of relative importance to the stated learning objectives (1 = Not relevant; 2 = Somewhat relevant; 3 = Quite relevant; 4 = Very relevant). They were also instructed to provide their feedback and comments to improve the questions. Agreement among experts was used to calculate the content validity index for each item (item content validly index [i-CVI]), where items with i-CVI values equal or less than 0.79 required revisions, and i-CVI values less than 0.70 were eliminated.[192,193] The first round of content validation was conducted with seven experts who reviewed the 33 questions. After revision, the second draft was composed of 26 questions (23 multiple choice questions; 3 open-ended questions). Seven questions were deleted because they were considered repetitive or did not fit with any of the learning objectives. A total of 12 questions were revised or reworded to improve clarity. Of the 33 questions, only six questions had a low level of agreement among experts (i-CVI = 71.4) (see Appendix E).

For the second round, the revised version of the knowledge test with 26 questions was shared with the experts to gather their feedback and collect any additional comments. Only three experts

agreed to participate in the second round. Minor grammatical modifications and comments were recommended for seven questions.

The knowledge test internal consistency and item difficulty index were assessed using the first 50 responses.[194] Items with an item difficulty index less than 0.2 or higher than 0.8 were eliminated or revised.[193] The internal consistency of the 26 items, using Cronbach's alpha (α), was 0.73. In terms of the item difficulty index, four items had a difficulty index of 0.9 or above and were deleted to allow for differentiation in learning. Two items had a difficulty index less than 0.2, the two items were retained and one of them was revised for clarify (10.a). The final draft of the knowledge test included 22 items:19 multiple-choice questions (MCQs) and 3 open-ended questions (see Appendix F). The final score was calculated out of 29 as follows: The score of the MCQ questions (out of 19) was automatically generated via Qualtrics, and the score for the open-ended questions (out of 10) was calculated based on a pre-validated grading rubric.

4.4 Results

4.4.1 Demographics of Participants

All pharmacists practising in Ontario who were registered users of Pharmacy5in5.ca were invited to participate in the trial. A total of 120 users agreed to participate and were randomized to the intervention group (60 participants) and the control group (60 participants). No statistically significant differences were found between the demographic characteristics of the two study groups (Table 4-1). Most respondents were female (78.3%), held a bachelor's degree (63.3%), received their training in Canada (72.5%), had more than 10 years of pharmacy practice experience (58.3%), and were practising in community pharmacies (70.8%). In terms of previous training,

96% of participants denied receiving any training related to anticholinergic toxicity in the past 12 months.

Table 4-1 Demographics of the control group and intervention group participants

Demographics	Intervention Group (*n* = 60)	Control Group (*n* = 60)
Years of pharmacy practice experience		
Less than 1 year	3 (5%)	6 (10%)
1–5 years	14 (23.3%)	13 (21.6%)
6–10 years	9 (15%)	5 (8.3%)
11–20 years	12 (20%)	15 (25%)
More than 20 years	22 (36.6%)	21(35%)
Gender		
Woman	44 (73.3%)	50 (83.3%)
Man	13 (21.6%)	8 (13.3%)
Prefer not to disclose	3 (5%)	2 (3.3%)
Location of qualifying pharmacy training		
Canada	45 (75%)	42 (70%)
United States	3 (5%)	5 (8.3%)
Outside North America	12 (20%)	13 (21.6%)
Highest level of education (e.g., BSc Pharm, entry level PharmD)		
Bachelor	38 (63.3%)	38 (63.3%)
Entry-level PharmD	10 (16.6%)	11 (18.3%)
Masters	4 (6.6%)	5 (8.3%)
Postgraduate PharmD	6 (10%)	3 (5%)
PhD	1 (1.6%)	1 (1.6%)
Other	1 (1.6%)	2 (3.3%)
Primary site of practice		
Community: Independent pharmacy	20 (33.3%)	22 (36.6%)
Community: chain or franchise	22 (36.6%)	21 (35%)
Hospital in-patient	9 (15%)	8 (13.3%)
Primary care clinic	4 (6.6%)	3 (5%)
Other	5 (8.3%)	6 (10%)
Training courses related to anticholinergic toxicity in the past 12 months		
Yes	0	1 (2.0%)
No	60 (100%)	58 (96.6%)
Maybe	0	1 (1.6%)

4.4.2 Loss to Follow Up

Of the 120 pharmacists who were randomized, all completed the pre-test and 101 (84.2%) completed the post-test. In particular, the post-test was completed by 83.3% (50/60) of the intervention group, and 85% (51/60) of the control group. There was no significant difference in baseline demographics of respondents and nonrespondents in the intervention group. There was no significant difference in the pre-test scores between respondents and nonrespondents in the intervention group (pre-test mean score 19.64 ± 3.49; pre-test mean score 17.9 ± 3.66; *p* value = 0.159). Similarly, in the control group, there was no significant difference in baseline demographics of respondents and nonrespondents, and no significant difference in the pre-test scores between respondents and nonrespondents (pre-test mean score 19.22 ± 3.37; pre-test mean score 19.22 ± 4.08; *p* value = 0.699).

4.4.3 Assessment of Access to the Anticholinergic Toxicity Module

Out of the 60 pharmacists allocated to the intervention group, 41 (68.3%) accessed the module and completed all seven quizzes, one user completed six out of the seven quizzes, one user completed five out of the seven quizzes, and 17 (25%) did not access the module at all. Of the 17 who did not access the module, seven completed the post-test.

On average, pharmacists in the intervention group spent 40 min to complete the quizzes of the module in a single session. Response data also showed that 15/43 (34.8%) of pharmacists completed the knowledge post-test within one day of completing the module quizzes, 26/43 (60%)

completed the knowledge post-test after one week of completing the module, and 2/43 (4.6%) completed the knowledge test after two weeks of completing the module quizzes.

4.4.4 Knowledge Test

As shown in Table 4-2, the mean score for the knowledge pre-test was 19.35 ± 3.56 (67%) in the intervention group and 19.22 ± 3.45 (66%) in the control group. There was no significant difference in the knowledge pre-test mean scores between the two groups (Mann–Whitney U: Z value = −0.018, $p = 0.985$). The mean score of the knowledge post-test increased significantly to 22.42 ± 3.812 (77%) in the intervention group and 23.29 ± 3.087 (80%) in the control group (Wilcoxon Signed Rank: Intervention group: Z value = −4.690, $p < 0.001$; Control group: value = −5.180, $p < 0.001$). However, there was no significant difference between the two study groups in the knowledge post-test (Mann–Whitney U: Z value = −0.968, $p = 0.333$).

In terms of individual questions, the two questions that had the lowest performance were those that addressed classifying patients according to their risk for serious anticholinergic side effects. In particular, only 16% of the participating pharmacists were able to identify that low dose doxepin (3 mg) is not a risk factor for serious anticholinergic side effects. Moreover, only 16.8% recognized that Parkinson's disease is not a risk factor for serious anticholinergic side effects. See Appendices G and H for subgroup analysis of post-test knowledge questions.

Table 4-2 Pre- and post- test scores

Pre-Test Score Out of 29 (Mean ± Standard Deviation)		*p* value [a]
Intervention group (*n* = 60)	Control group (*n* = 60)	0.985
19.35 ± 3.56	19.22 ± 3.45	
Post-test score out of 29 (Mean ± Standard Deviation)		

	Intervention group (n = 50)	Control group (n = 51)	
	22.42 ± 3.812	23.29 ± 3.087	0.333
p value [b]	<0.001	<0.001	

[a] Mann–Whitney U; [b] Wilcoxon signed ranks.

4.5 4. Discussion

This randomized controlled trial assessed Ontario pharmacists' knowledge of anticholinergic toxicity after completion of a computer-based education module. One of the key findings is that the computer-based education module improved pharmacists' knowledge significantly ($p < 0.001$). This result is consistent with previous studies conducted among nurses and physicians.[74-76] Moreover, the study showed that there was no difference between a paper-based decision aid by RxFiles and a computer-based education module in improving pharmacists' knowledge of anticholinergic toxicity, as there was no significant difference in post-test scores between the study groups ($p = 0.333$). Surprisingly, the study found that the topic of anticholinergic toxicity is not commonly addressed in pharmacy professional trainings with only 4% of participants reporting having received training related to the topic in the past 12 months. Given that anticholinergic medications are problematic in an aging population, and that the primary users of medications are the elderly, pharmacists are required to have the ability to address any drug-related problems that arise with the use of these medications. The Pharmacy5in5 platform offers busy pharmacists the opportunity to easily access modules via an online platform and test their knowledge and receive feedback on their behaviours.

This study contributes to existing literature with few studies comparing the effect of computer-based education to printed educational material among pharmacists. In a recent scoping review of the effect of computer-based education on health care providers' knowledge skills and behaviour,

a total of 14 studies assessed knowledge gain.[179] Only one study targeting pharmacists was identified. Nesterowicz et al.[89] compared computer-based education to a two-hour on-site session on improving pharmacists' knowledge of blood pressure monitoring. The authors assessed knowledge gain after six months. Similar to our study, the increase in knowledge in both groups was significant by 29% in the intervention group and 27.2% in the control group, but the groups did not differ significantly, indicating that online learning is as effective as on-site learning. Pharmacists in the study had low pre-test scores indicating more room for improvement in their knowledge. Despite the difference in topic addressed, this indicates that computer-based education could promote knowledge retention among pharmacists and that there should be a move towards readily available, easily accessible, self-directed computer-based education, especially during the COVID-19 pandemic.

While this study indicated that computer-based education is an appropriate intervention to educate pharmacists on anticholinergic toxicity, the knowledge gained is not necessarily translated into clinical practice.[195] A successful behaviour change intervention should address barriers and facilitators to promote practice change.[196] As such, computer-based education could alter pharmacists' behaviour by addressing unique barriers to reducing anticholinergic burden. A 2021 systematic review by Stewart et al.[197] identified a number of barriers among pharmacists including lack of confidence in skills and uncertainty about the need for reducing anticholinergic burden. The *Anticholinergic Toxicity* module used in this study could help pharmacists overcome these barriers through the six case based quizzes to build confidence, and the animated video emphasizing the consequences of anticholinergic toxicity.[198] Therefore, computer-based education

could be tailored to address barriers using different design components, making it a promising intervention to optimize the use of anticholinergic medications.

4.5.1 Strengths and Limitations

A strength of this study was a low dropout rate of 15.8% despite being conducted during the COVID-19 pandemic, as compared to other studies among healthcare professionals that reported dropout rates of 31% [199] and 47%.[200] This suggests that there is high feasibility for conducting online interventions with pharmacists. The dropout rate in both the intervention and control groups was similar, which suggests that both the printed and computer-based education platform were desirable. A second strength of the study was the triangulation of the post-test knowledge scores with the usage of the platform, where 86% of the users who completed the post-test had completed the module. Another study strength was the low level of contamination bias as only 1 out of 101 users reported that they knew other pharmacists who participated in the study, and 9 users were unsure. However, all users reported that they did not discuss their group allocation with a colleague, nor knew whether they were assigned to a different group. A potential limitation is that the content of the education modules was focused on a single topic (anticholinergic toxicity), with a plan for future work to assess other pharmacy practice-related content to demonstrate the generalizability of the effect of computer-based education on pharmacists' knowledge. Another limitation, is the limited ability to control or monitor the use of additional resources while completing the post-tests. Moreover, there was limited ability to confirm whether the control group users completed the paper-based material before completing the post-knowledge tests. Another

potential limitation is selection bias, with the possibility that only pharmacists who were interested in the topic agreed to participate in the study.[201]

4.5.2 Practical Implications and Future Research

This study provided much needed information about the effectiveness of the computer-based education platform in improving pharmacists' knowledge. The results also act as a feasibility study for a future study of how the website supports behaviour change and practice outcomes. Pharmacy5in5 is anticipated to be a highly impactful platform with the potential to advance the field of professional continuing education for pharmacists.

4.6 Conclusions

This study evaluated the effectiveness of a computer-based education module compared to a paper-based education in improving pharmacists' knowledge of anticholinergic toxicity. The study highlighted that computer-based education can improve pharmacists' knowledge similarly to printed education material. Further research is needed to assess the potential of computer-based education in improving pharmacists' knowledge in non-clinical topics such as ethics and policies, as well as assessing if knowledge gained from computer-based education is retained and implemented in pharmacy practice.

4.7 Author Contributions

Conceptualization, R.H. and K.G.; Data curation, R.H. and K.G.; Formal analysis, R.H. and Z.H.; Investigation, R.H.; Methodology, Z.H., J.B., T.P., R.K. and K.G.; Supervision, K.G.; Validation, J.B., T.P., R.K. and K.G.; Writing—Original draft, R.H.; Writing—Review and editing, R.H.,

Z.H., T.P., R.K. and K.G. All authors have read and agreed to the published version of the manuscript.

4.8 Funding

This research received no external funding.

4.9 Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of the University of Waterloo Ethics Committee (ORE # 42710).

4.10 Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

4.11 Conflicts of Interest

The authors declare no conflicts of interest.

Additional context

For this thesis, this chapter was the first attempt to evaluate the Pharmacy5in5 platform and to provide outcome information on the effect of the platform on pharmacists' knowledge. In particular, this study focused on assessing the effect of the platform on pharmacists' knowledge of anticholinergic toxicity. To develop the anticholinergic toxicity module, four experts, including one geriatric pharmacist, were involved in the development of the module infographics, videos and flashcards. The content developers started by drafting the learning objectives. Next, two infographics, one video and five flashcards were developed. I drafted one fast facts quiz and six case-base quizzes and sent them to the experts to assess the face validity of the items. The questions included in the module's quizzes were different from the pre- and post-intervention knowledge test questions. As highlighted in the paper, this module was designed specifically for this trial and had not been released to other platform users.

With regards to the control group, the printed educational material was chosen based on the recommendation of the content experts. As outlined in the paper, the two printed educational materials were also used as references in the development of the Pharmacy5in5 online module content to ensure the content of the printed material was similar to the module content.

Chapter 5

Discussion and Conclusion

5.1 Overview

There is great interest in the use of CBE in HCP education as an alternative to traditional learning. The bulk of existing literature focuses on educating students, leaving little information about how CBE influences practicing professionals such as pharmacists. Moreover, studies investigating the effects of CBE on HCPs often focus on physicians and nurses. To address this gap, this thesis explores the effect of CBE on pharmacy professionals' knowledge, skills, and behaviour. The thesis also explores how to use behaviour change theories to refine CBE platforms designed for pharmacy professionals. Throughout this exploration, the thesis provides guidance for computer-based education designers on how to develop a theoretically-informed behaviour change intervention to support practice change. The thesis also provides strong evidence on the effect of fully online CBE on improving pharmacists' knowledge. CBE was found to be as effective as printed educational material in delivering education for pharmacists. Overall, the value of CBE became clear in improving knowledge, and future research is needed to explore the effect of CBE on pharmacy professionals' behaviour and practice change.

The scoping review in **Chapter 2** focused on CBE that is delivered fully online. The review highlighted the positive effect of fully online CBE on physicians' and nurses' knowledge and skills. However, the review reported a lack of rigorously designed randomised controlled trials evaluating the effectiveness of fully online CBE on HCP clinical behaviour and patient outcomes. Moreover, the review highlighted limited research assessing the effectiveness of fully

online CBE on pharmacists' knowledge, skills, and clinical behaviour. Hence, and based on findings of this chapter, **Chapter 4** was conducted to explore the effect of the CBE platform, *Pharmacy5in5*, on pharmacists' knowledge using an RCT.

This scoping review also focused on providing more detailed descriptions of CBE components and features. For example, the review highlighted the most common features included in fully online CBE targeting experienced HCPs such as discussion forums, assessment questions and case study quizzes. These three features were also reported in **Chapter 3** as an application of BCTs to CBE. As shown in Table 3-3, case study quizzes were proposed as an application of the BCT "*behavioural rehearsal/practice*" to address lack of skills or confidence. Discussion forums were proposed as an application of the BCTs "*social support*" and "*social comparison*" where users from different provinces can connect and ask questions to address social influences and build a stronger professional identity. Interactivity through discussion forums was found to be particularly useful to overcome challenges associated with CBE such as learner isolation and lack of educator support.[67,69] This suggests the benefits of using discussion forums, among other key features, in fully online CBE. Similar results were reported in a study conducted with pharmacists in Alberta to explore their experience with a continuing professional development course delivered online.[28] Pharmacists reported that they appreciated the chance to connect and interact with experts and peers to discuss cases. Similarly, Carroll et al.[39] reported that the ability to interact with peers via discussion forums can create a sense of belonging and boost confidence. Building on finding from **Chapters 2 and 3**, online discussion boards could be

a promising design feature to add to *Pharmacy5in5* to enhance users' engagement with the platform and promote practice change.

Chapter 3 of this thesis focuses on identifying barriers and facilitators of full scope services among pharmacy professionals. Findings of this study reported a number of useful BCTs to address identified barriers and accelerate the adoption of full scope services by pharmacy professionals. The importance of this study stemmed from the value of using the TDF theoretical lens to identify barriers and facilitators of full scope services beyond lack of time and adequate staff. Second, the generated list of BCTs can be applied to other modules in the platform to address unique barriers and facilitators (Table 3-3). Addressing barriers and facilitators is essential for the success of the platform because users may acquire intended knowledge and skills from the platform, but face barriers that hinder the application and translation of knowledge into practice. As such, each module in *Pharmacy5in5* could include a different set of design features to address unique corresponding barriers and facilitators. Therefore, when designing future modules for *Pharmacy5in5*, reviewing the literature to identify possible barriers and facilitators for desired behaviours could guide the selection of design components.

Chapter 4 assessed the effectiveness of the CBE platform *Pharmacy5in5* in increasing pharmacists' knowledge compared to traditional printed material. This study is important for four reasons. First, as each platform uses a unique combination of design components and has different levels of support and learning objectives, each platform should be evaluated within its own context.[34] Therefore, this study helped answer the question regarding whether the

Pharmacy5in5 platform itself is effective. Second, this study demonstrated the effectiveness of fully online CBE in improving knowledge, which contradicts evidence claiming that fully online CBE is less effective than traditional learning.[26,37] Third, as *Pharmacy5in5* is designed to be used as a replacement for, not an aid to traditional educational methods, comparison with traditional learning such as printed material was necessary to establish its value.[26] Finally, this study provided a model for evaluation of *Pharmacy5in5* modules that can be easily replicated with other topics in the platform.

Chapter 4 showed a statistically significant improvement in knowledge in the intervention group with a knowledge gain of 13.7%, which is in line with the range of knowledge gain reported in the literature among pharmacy professionals (7-46%).[34] While some might argue that the change is not huge, it does demonstrate the effectiveness of the platform on increasing knowledge. Furthermore, baseline knowledge of pharmacists was adequate in this topic, giving smaller room for improvement. It is anticipated that a much more significant knowledge gain could have been achieved with less well-known or newer topics where pharmacists have less baseline knowledge.

5.2 Challenges with conducting web-based RCTs

Chapter 4 was conducted using a web-based parallel RCT, where the intervention, a *Pharmacy5in5* module, was offered online and outcome measures were collected remotely. The web-based trial allowed busy pharmacy professionals to participate in the RCT without needing to travel to research settings and facilitated a standardized delivery of the intervention.[202,203] Conducting the RCT using *Pharmacy5in5* offered also several advantages. For example, the

platform has been adopted by more than 13,000 pharmacists and pharmacy technicians across Canada, which facilitated the recruitment of study participants for the RCT. Recruitment is usually one of the major barriers for completing RCTs, with only half of trials achieving their recruitment target.[204] However, this was not a major issue with *Pharmacy5in5* users which could be attributed to the regular communication with users to share updates about the platform which promotes engagement and builds rapport with users.[203] Moreover, accessibility to the data generated automatically by the platform provided useful insights into users' adherence to the RCT protocol. Furthermore, accessibility to registered users' demographic data allowed the assessment of non-response bias in surveys and the knowledge test.

A major challenge with conducting a web-based RCT with pharmacy professionals is retention to follow up. A high dropout rate with web-based trials is well documented in the literature among health professionals.[37,184] A monetary incentive is one approach to improve users' retention in general. [205-207] A 2021 review by Gillies et al.[205] on strategies to improve retention in randomized trials reported a higher retention with higher value monetary incentives. In the review, reported monetary incentives such as cash or vouchers ranged from US$2 to US$35. Khadjesari et al.[207] reported that monetary incentives of sufficient value may enhance retention and survey completion rate. In the study in **Chapter 4**, pharmacists were offered a $15 gift card as an appreciation for their participation. However, further research is needed to assess the dollar value and type of incentives that can improve retention rate with pharmacy professionals in particular. Furthermore, there is a need to explore nonmonetary incentives such as certificates of appreciation to boost retention rate among pharmacy professionals.

Contamination is another challenge, defined as the receipt of active intervention amongst participants in the control arm, which could dilute the effect of the intervention.[186,208] In **Chapter 4**, a number of methods were used in order to minimize the risk of contamination. First, two different researchers were involved in the study, with one researcher responsible for contacting the intervention group and providing the link to access the *Anticholinergic Toxicity* module, and another researcher being responsible for contacting the control group to provide the printed education material. Second, in the information sheet, users were clearly instructed not to disclose what group they were in to the members of the research team or other pharmacists, and to use their participant study ID for any future communications with the research team. Third, as explained in **Chapter 4** (page 105; paragraph 2), the *Anticholinergic Toxicity module* was designed for this trial and only users in the intervention group had access to it. Moreover, data tracking users' access to the platform showed that none of the users in the control group had attempted or had access to the module. Finally, in order to assess contamination, users were asked to report if they knew any of the other participants in the study; if they did, they were asked to report if they discussed group allocation with them.

5.3 Challenges with mixed methods research

The use of mixed methods research is associated with a number of challenges. One challenge is related to how to best design the study. In **Chapter 3**, a sequential mixed methods approach was taken, where the study started with a survey including 225 participants, followed by telephone interviews with 24 survey respondents. Given the large number of TDF domains (12 domains) and pharmacy and pharmacy technician behaviours (9 behaviours), the sequential approach

helped narrow the focus on key TDF domains and behaviours allowing more in-depth understating of barriers and facilitators. For example, building on the quantitative analysis, the interview guide was mostly focused on discussing barriers of "independent prescribing" and "minor ailments prescribing" rather than "adaptation" and "renewal".

Another challenge faced was on how to use contradicting data to draw conclusions. For example, in **Chapter 3** regarding the domain 'emotions', more than 40 % of the survey participants agreed or strongly agreed that performing full scope activities was stressful. Stress was also discussed heavily in the qualitative analysis, but it was mostly referred to as "good stress" that kept participants motivated and sharp. Hence, the 'emotions' domain was not considered a barrier to full scope services. As such, triangulation of the quantitative and qualitative data helped build more informed explanations of inconsistences and provided richer clarification of the results.

Establishing trustworthiness or validity of the mixed research findings was another challenge. Options to address this concern include triangulation and member checking.[142] In **Chapter 3**, for example, the validity of findings was established by ensuring the validity of the qualitative and quantitative components of the study. As such, the survey validity was established by using a pre-validated survey, followed by conducting a think-aloud protocol with users and finally by piloting the survey. On the other hand, trustworthiness of the qualitative data was established by using two independent data coders and a clear coding book to ensure dependability; using triangulation of the qualitative findings with quantitative findings to ensure

credibility and confirmability; and using member checking by sharing results with respondents to ensure credibility.

5.4 Implications and future research

This thesis assists researchers and designers involved in the development of CBE platforms, especially platforms designed for pharmacy professionals. Guided by theory, the thesis identifies a number of potential BCTs that can be incorporated to CBE and provided valuable insights into how to translate BCTs to design components. This will allow designers make informed decisions about which BCTs to consider for behaviour change interventions targeting pharmacy professionals. This thesis also provides detailed descriptions for a number of key CBE design features. However, there is still a need for more detailed guidelines focusing on what CBE features should be selected to target experienced HCPs and how to select these features. In addition, further research is needed on which combination of features could provide optimal educational outcomes.

One of the major challenges with CBE is to demonstrate its ability to translate knowledge into practice. This thesis has shown that the online asynchronous CBE, *Pharmacy5in5*, is an appropriate venue for pharmacists' education and is as effective as printed education material in producing knowledge change. However, further research is needed to assess knowledge retention and behaviour change. As such, robust, large-scale randomized controlled trials equipped with validated objective measures for behaviour are needed. To improve understanding of the effectiveness of *Pharmacy5in5*, future research should compare this platform against other alternative educational methods with similar content and duration of exposure. Future studies

could also assess effectiveness of different versions of the platform with different design components to provide much needed information about the best design components to enhance knowledge retention and behaviour change for pharmacy professionals.

5.5 Strengths and limitations

In addition to the limitations mentioned in the previous chapters, one major limitation was recruiting pharmacy professional during the COVID-19 pandemic. With most pharmacy professionals occupied with vaccination clinics and other duties, fewer were interested in completing surveys or interviews. Of the pharmacy professionals who had time and were interested, all their interviews were conducted over the phone rather than in person. However, telephone interviews provided similar in-depth information as in person interviews, with the added benefits of more flexibility and lower cost.[209] Current studies included users of *Pharmacy5in5* only. Future research could focus on recruiting a more diverse population of pharmacists to maximize the generalizability of findings. Furthermore, as there are plans is to expand the availability of the platform to all HCPs, future studies will have the opportunity to recruit other HCPs such as nurses and physicians to establish the effect of CBE among HCPs in Canada.

Another limitation was related to mapping individual and organizational factors to relevant BCTs that can be delivered via CBE. The thesis provides several examples that can address individual factors such as lack of skill and confidence via CBE. However, it was not feasible nor practical to address organizational factors such as limited managerial support via

CBE. Further investigations are needed to explore other measures in addition to CBE to address all possible barriers and facilitators.

This thesis has several strengths. First, the thesis used the TDF theoretical lens which provided a method to progress from investigation to designing intervention. The application of the TDF was based on the guidance of Atkin et al.[130] which provided a step-by-step systematic approach to guide designers of implementation interventions in the development process. Moreover, the thesis provided examples of how to operationalize BCTs using CBE which are applicable to other behaviours and contexts. Another key strength was the use of mixed methods research, which as explained above, provided richer data, and more in-depth understanding. A final key strength was the use of a randomized controlled trial to assess the effect of CBE on knowledge. Findings were reported using the CONSORT-EHEALTH checklist to ensure that the trial design was appropriate. Moreover, the use of a control group with educational content on the same topic as the intervention group showed that the improvement in knowledge in the intervention group was attributed to delivery of the education via CBE (the same references and sources that were used to create the educational materials for the control group were used to create the module content for the intervention group). Of note, the control group that was used in **Chapter 4** had access to superior, rather than standard printed education materials, as it included a chart from RxFiles, which is a powerful decision aid chart. As such, the effect of *Pharmacy5in5* may have been underestimated.

5.6 *Pharmacy5in5*: upgrades and improvements

Pharmacy5in5 platform was developed with a set of unique design features that were added based on a number of theories. For example, the case-based quizzes are based on a fictional persona of a pharmacist or pharmacy technician, which provides a narrative model for a pharmacy professional performing full scope services in practice. This feature is based on the behaviour change technique "modeling" which originates from Bandura's social cognitive theory.[210] Another feature is peer comparison, where users can compare their performance to other pharmacy professionals who completed the same quiz. This feature is based on the behaviour change technique "social comparison" of the social cognitive theory.[210] The self-reflection feature is added at the end of each case-based quiz to encourage users to answer a question about their past behaviour. This feature is based on the behaviour change technique "self-monitoring" of the control theory.[211]

A number of new features were added to the platform while I was evaluating it, including a statement of completion, social rewards, badges and trophies. These features were added with aim of improving users' engagement with the platform and to enhance quiz completion rates, but not to influence clinical behaviour. These features will be evaluated in future studies.

For future, and building on the results of **Chapter 3,** additional features need to be added to the platform to support behaviour change. These include peer support and modeling which were heavily discussed among our users. Peer support can be added through the addition of discussion forums/boards. As highlighted in **Chapter 2**, discussion forums were one of the most commonly reported features in CBE targeting experienced HCPs. Moreover, there is a strong consensus in

literature on the positive effect of discussion boards on learning outcomes.[24,39,40] Modeling can include the narrative models in quizzes, but can be expanded to include videos showing other pharmacy professionals interacting with patients and demonstrating a full scope activity. Modeling via videos would allow most users to visually see how a new service can be implemented in practice. Moreover, there is growing literature on the positive effect of modeling videos on healthcare professionals' performances and competencies.[212,213] Overall, adding different features would help tailor Pharamcy5in5 to address users' different learning needs and hence improve their learning opportunities and experiences.[214,215]

5.7 Conclusion

The question regarding how to design fully online CBE for HCPs to enhance their knowledge and behaviour is timely because of the COVID-19 pandemic. This thesis provides stepwise guidance on how to design theory-based interventions that can be delivered via CBE. The thesis also provides outcome information on the effect of fully online CBE on improving pharmacists' knowledge. Future research should focus on measuring knowledge retention, behaviour change and patient outcomes. Moreover, the findings will help tailor future *Pharmacy5in5* modules to target factors that may be interfering with the desired behaviour, which will improve the success and effectiveness of the platform. An effective platform will reduce pharmacists' perceived barriers to service provision and optimize pharmacists' behaviour, leading to improved patient outcomes and quality of life.

References

1. Tsuyuki RT, Houle SK, Okada H. Time to give up on expanded scope of practice. In. Vol 151: SAGE Publications Sage CA: Los Angeles, CA; 2018:286-286.
2. de Barra M, Scott CL, Scott NW, et al. Pharmacist services for non-hospitalised patients. *The Cochrane database of systematic reviews.* 2018;9:Cd013102.10.1002/14651858.Cd013102
3. Weeks G, George J, Maclure K, Stewart D. Non-medical prescribing versus medical prescribing for acute and chronic disease management in primary and secondary care. *Cochrane Database of Systematic Reviews.* 2016(11).
4. Tong E, Roman C, Mitra B, et al. Partnered pharmacist charting on admission in the General Medical and Emergency Short-stay Unit–a cluster-randomised controlled trial in patients with complex medication regimens. *Journal of clinical pharmacy and therapeutics.* 2016;41(4):414-418.
5. De Oliveira GS, Jr., Castro-Alves LJ, Kendall MC, McCarthy R. Effectiveness of Pharmacist Intervention to Reduce Medication Errors and Health-Care Resources Utilization After Transitions of Care: A Meta-analysis of Randomized Controlled Trials. *Journal of patient safety.* 2017.10.1097/pts.0000000000000283
6. Touchette DR, Doloresco F, Suda KJ, et al. Economic evaluations of clinical pharmacy services: 2006-2010. *Pharmacotherapy.* 2014;34(8):771-793.10.1002/phar.1414
7. Currie K, Evans C, Mansell K, Perepelkin J, Jorgenson D. Community pharmacists' experiences with the Saskatchewan Medication Assessment Program. *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2019;152(3):193-203.
8. Tsuyuki RT, Bond C. The evolution of pharmacy practice research-Part I: Time to implement the evidence. *Canadian pharmacists journal : CPJ = Revue des pharmaciens du Canada : RPC.* 2019;152(2):71-72.10.1177/1715163519828318
9. Dolovich L, Consiglio G, MacKeigan L, et al. Uptake of the MedsCheck annual medication review service in Ontario community pharmacies between 2007 and 2013. *Canadian pharmacists journal : CPJ = Revue des pharmaciens du Canada : RPC.* 2016;149(5):293-302.10.1177/1715163516662670
10. MacCallum L, Consiglio G, MacKeigan L, Dolovich L. Uptake of community pharmacist-delivered MedsCheck diabetes medication review service in Ontario between 2010 and 2014. *Canadian Journal of Diabetes.* 2017;41(3):253-258.
11. Kolhatkar A, Cheng L, Chan FK, Harrison M, Law MR. The impact of medication reviews by community pharmacists. *Journal of the American Pharmacists Association : JAPhA.* 2016;56(5):513-520.e511.10.1016/j.japh.2016.05.002
12. Forsetlund L, Bjorndal A, Rashidian A, et al. Continuing education meetings and workshops: effects on professional practice and health care outcomes. *The Cochrane database of systematic reviews.* 2009(2):Cd003030.10.1002/14651858.CD003030.pub2
13. Arditi C, Rège-Walther M, Durieux P, Burnand B. Computer-generated reminders delivered on paper to healthcare professionals: effects on professional practice and healthcare outcomes. *Cochrane Database of Systematic Reviews.* 2017(7).
14. O'Brien MA, Rogers S, Jamtvedt G, et al. Educational outreach visits: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews.* 2007(4).10.1002/14651858.CD000409.pub2
15. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database of Systematic Reviews.* 2012(6).10.1002/14651858.CD000259.pub3

16. Fonhus MS, Dalsbo TK, Johansen M, Fretheim A, Skirbekk H, Flottorp SA. Patient-mediated interventions to improve professional practice. *The Cochrane database of systematic reviews.* 2018;9:Cd012472.10.1002/14651858.CD012472.pub2
17. Giguere A, Legare F, Grimshaw J, et al. Printed educational materials: effects on professional practice and healthcare outcomes. *The Cochrane database of systematic reviews.* 2012;10:Cd004398.10.1002/14651858.CD004398.pub3
18. Trewet CB, Fjortoft N. Evaluation of the impact of a continuing professional development worksheet on sustained learning and implementing change after a continuing pharmacy education activity. *Research in Social and Administrative Pharmacy.* 2013;9(2):215-221.https://doi.org/10.1016/j.sapharm.2012.06.002
19. Wheeler JS, Chisholm-Burns M. The benefit of continuing professional development for continuing pharmacy education. *American journal of pharmaceutical education.* 2018;82(3).
20. Lawn S, Zhi X, Morello A. An integrative review of e-learning in the delivery of self-management support training for health professionals. *BMC Med Educ.* 2017;17(1):183-183.10.1186/s12909-017-1022-0
21. Regmi K, Jones L. A systematic review of the factors–enablers and barriers–affecting e-learning in health sciences education. *BMC Med Educ.* 2020;20(1):1-18.
22. Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, Montori VM. Internet-based learning in the health professions: a meta-analysis. *Jama.* 2008;300(10):1181-1196.
23. Sherman H, Comer L, Putnam L, Freeman H. Blended versus lecture learning: outcomes for staff development. *Journal for Nurses in Professional Development.* 2012;28(4):186-190.
24. Scott KM, Baur L, Barrett J. Evidence-based principles for using technology-enhanced learning in the continuing professional development of health professionals. *Journal of Continuing Education in the Health Professions.* 2017;37(1):61-66.
25. Lawn S, Zhi X, Morello A. An integrative review of e-learning in the delivery of self-management support training for health professionals. *BMC Med Educ.* 2017;17(1):1-16.
26. Ruggeri K, Farrington C, Brayne C. A global model for effective use and evaluation of e-learning in health. *Telemedicine and e-Health.* 2013;19(4):312-321.
27. Lorenzoni AA, Manzini F, Soares L, Leite SN. E-learning in Pharmacy Education: what do we know about it? *Brazilian Journal of Pharmaceutical Sciences.* 2019;55.
28. Hughes CA, Schindel TJ. Evaluation of a professional development course for pharmacists on laboratory values: can practice change? *International Journal of Pharmacy Practice.* 2010;18(3):174-179.
29. Namara KPM, Marriott JL, Duncan GJ. What makes continuing education effective: perspectives of community pharmacists. *International Journal of Pharmacy Practice.* 2007;15(4):313-317.
30. Berndt A, Murray CM, Kennedy K, Stanley MJ, Gilbert-Hunt S. Effectiveness of distance learning strategies for continuing professional development (CPD) for rural allied health practitioners: a systematic review. *BMC Med Educ.* 2017;17(1):1-13.
31. Childs S, Blenkinsopp E, Hall A, Walton G. Effective e-learning for health professionals and students—barriers and their solutions. A systematic review of the literature—findings from the HeXL project. *Health Information & Libraries Journal.* 2005;22:20-32.
32. Lahti M, Hätönen H, Välimäki M. Impact of e-learning on nurses' and student nurses knowledge, skills, and satisfaction: a systematic review and meta-analysis. *International journal of nursing studies.* 2014;51(1):136-149.
33. Sinclair PM, Kable A, Levett-Jones T, Booth D. The effectiveness of Internet-based e-learning on clinician behaviour and patient outcomes: a systematic review. *International journal of nursing studies.* 2016;57:70-81.

34. Salter SM, Karia A, Sanfilippo FM, Clifford RM. Effectiveness of E-learning in pharmacy education. *American journal of pharmaceutical education.* 2014;78(4):83.https://doi.org/10.5688/ajpe78483
35. Du S, Liu Z, Liu S, et al. Web-based distance learning for nurse education: a systematic review. *International nursing review.* 2013;60(2):167-177.
36. Richmond H, Copsey B, Hall AM, Davies D, Lamb SE. A systematic review and meta-analysis of online versus alternative methods for training licensed health care professionals to deliver clinical interventions. *BMC Med Educ.* 2017;17(1):1-14.
37. Vaona A, Banzi R, Kwag KH, et al. E-learning for health professionals. *The Cochrane database of systematic reviews.* 2018;1:Cd011736.10.1002/14651858.CD011736.pub2
38. Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, Montori VM. Instructional design variations in internet-based learning for health professions education: a systematic review and meta-analysis. *Academic medicine.* 2010;85(5):909-922.
39. Carroll C, Booth A, Papaioannou D, Sutton A, Wong R. UK health-care professionals' experience of on-line learning techniques: A systematic review of qualitative data. *Journal of Continuing Education in the Health professions.* 2009;29(4):235-241.
40. Morrison LG, Yardley L, Powell J, Michie S. What design features are used in effective e-health interventions? A review using techniques from critical interpretive synthesis. *Telemedicine and e-Health.* 2012;18(2):137-144.
41. Paliadelis PS, Stupans I, Parker V, et al. The development and evaluation of online stories to enhance clinical learning experiences across health professions in rural Australia. *Collegian.* 2015;22(4):397-403.
42. Haigh C, Hardy P. Tell me a story—a conceptual exploration of storytelling in healthcare education. *Nurse education today.* 2011;31(4):408-411.
43. Deterding S, Dixon D, Khaled R, Nacke L. From game design elements to gamefulness: defining "gamification". Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments; 2011; Tampere, Finland.10.1145/2181037.2181040
44. Zichermann G, Cunningham C. *Gamification by design implementing game mechanics in web and mobile apps.* Sebastopol (Calif.); Beijing; Cambridge: O'Reilly; 2011.
45. Albertazzi D, Ferreira MGG, Forcellini FA. A Wide View on Gamification. *Technology, Knowledge and Learning.* 2018.10.1007/s10758-018-9374-z
46. Sardi L, Idri A, Fernandez-Aleman JL. A systematic review of gamification in e-Health. *Journal of biomedical informatics.* 2017;71:31-48.10.1016/j.jbi.2017.05.011
47. Seaborn K, Fels DI. Gamification in theory and action: A survey. *Int J Hum-Comput Stud.* 2015;74:14-31.0.1016/j.ijhcs.2014.09.006
48. Hamari J, Koivisto J, Sarsa H. Does gamification work?--a literature review of empirical studies on gamification. Paper presented at: 2014 47th Hawaii international conference on system sciences2014.1479925047
49. Ryan RM, Deci EL. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology.* 2000;25(1):54-67.
50. Jung J, Schneider C, Valacich J. Enhancing the motivational affordance of information systems: The effects of real-time performance feedback and goal setting in group collaboration environments. *Management science.* 2010;56(4):724-742.
51. Ryan RM, Rigby CS, Przybylski A. The motivational pull of video games: A self-determination theory approach. *Motivation and emotion.* 2006;30(4):344-360.
52. Mitchell R, Schuster L, Drennan J. Understanding how gamification influences behaviour in social marketing. *Australasian Marketing Journal (AMJ).* 2017;25(1):12-19.

53. Deci EL, Ryan RM. Self-determination theory. 2012.
54. Deci EL, Ryan RM. Overview of self-determination theory: An organismic dialectical perspective. *Handbook of self-determination research.* 2002:3-33.
55. Vansteenkiste M, Niemiec CP, Soenens B. The development of the five mini-theories of self-determination theory: An historical overview, emerging trends, and future directions. In: *The decade ahead: Theoretical perspectives on motivation and achievement.* Emerald Group Publishing Limited; 2010:105-165.
56. Rigby S, Ryan RM. *Glued to games: How video games draw us in and hold us spellbound: How video games draw us in and hold us spellbound.* AbC-CLIo; 2011.
57. Sailer M, Hense JU, Mayr SK, Mandl H. How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior.* 2017;69:371-380.
58. Wee S-C, Choong W-W. Gamification: Predicting the effectiveness of variety game design elements to intrinsically motivate users' energy conservation behaviour. *Journal of environmental management.* 2019;233:97-106.
59. Peng W, Lin J-H, Pfeiffer KA, Winn B. Need satisfaction supportive game features as motivational determinants: An experimental study of a self-determination theory guided exergame. *Media Psychology.* 2012;15(2):175-196.
60. McKeown S, Krause C, Shergill M, Siu A, Sweet D. Gamification as a strategy to engage and motivate clinicians to improve care. *Healthcare management forum.* 2016;29(2):67-73.10.1177/0840470415626528
61. Sinclair P, Kable A, Levett-Jones T. The effectiveness of internet-based e-learning on clinician behavior and patient outcomes: a systematic review protocol. *JBI Database System Rev Implement Rep.* 2015;13(1):52-64.10.11124/jbisrir-2015-1919
62. Turner M, Payne S, Froggatt K. All tooled up: an evaluation of end of life care tools in care homes in North Lancashire. *End of Life Care.* 2009;3(4):59-59.
63. Nacioglu A. As a critical behavior to improve quality and patient safety in health care: speaking up! *Safety in Health.* 2016;2(1):10.
64. Johnson MJ, May CR. Promoting professional behaviour change in healthcare: what interventions work, and why? A theory-led overview of systematic reviews. *BMJ open.* 2015;5(9):e008592.
65. Roh KH, Park H-A. A meta-analysis on the effectiveness of computer-based education in nursing. *Healthc Inform Res.* 2010;16(3):149-157.10.4258/hir.2010.16.3.149
66. Guze PA. Using technology to meet the challenges of medical education. *Transactions of the American clinical and climatological association.* 2015;126:260-270.
67. Reeves S, Fletcher S, McLoughlin C, Yim A, Patel KD. Interprofessional online learning for primary healthcare: findings from a scoping review. *BMJ open.* 2017;7(8):e016872.10.1136/bmjopen-2017-016872
68. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of e-learning in medical education. *Academic medicine.* 2006;81(3):207-212.
69. McCabe C, Patel KD, Fletcher S, et al. Online interprofessional education related to chronic illness for health professionals: a scoping review. *Journal of Interprofessional Care.* 2020:1-10.
70. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *International journal of social research methodology.* 2005;8(1):19-32.
71. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Annals of internal medicine.* 2018;169(7):467-473.
72. Kirkpatrick JD, Kirkpatrick WK. *Kirkpatrick's four levels of training evaluation.* Association for Talent Development; 2016.

73. Gordon JS, Mahabee-Gittens EM, Andrews JA, Christiansen SM, Byron DJ. A randomized clinical trial of a web-based tobacco cessation education program. *Pediatrics.* 2013;131(2):e455-e462.
74. Sinclair PM, Kable A, Levett-Jones T, Holder C, Oldmeadow CJ. An evaluation of general practice nurses' knowledge of chronic kidney disease risk factors and screening practices following completion of a case study-based asynchronous e-learning module. *Australian Journal of Primary Health.* 2019;25(4):346-352.
75. Bentley MW, Kerr R, Ginger M, Karagoz J. Behavioural change in primary care professionals undertaking online education in dementia care in general practice. *Australian Journal of Primary Health.* 2019;25(3):244-249.
76. Van de Steeg L, IJkema R, Langelaan M, Wagner C. Can an e-learning course improve nursing care for older people at risk of delirium: a stepped wedge cluster randomised trial. *BMC geriatrics.* 2014;14(1):69.
77. Rankin JA, Then KL, Atack L. Can emergency nurses' triage skills be improved by online learning? Results of an experiment. *Journal of Emergency Nursing.* 2013;39(1):20-26.
78. Kim JH, Shin JS. Effects of an online problem-based learning program on sexual health care competencies among oncology nurses: a pilot study. *The Journal of Continuing Education in Nursing.* 2014;45(9):393-401.
79. Pelayo M, Cebrián D, Areosa A, Agra Y, Izquierdo JV, Buendía F. Effects of online palliative care training on knowledge, attitude and satisfaction of primary care physicians. *BMC family practice.* 2011;12(1):37.
80. Wong A, Vohra R, Dawson AH, Stolbach A. Impact of online toxicology training on health professionals: the Global Educational Toxicology Uniting Project (GETUP). *Clinical toxicology.* 2017;55(9):981-985.
81. de Ruijter D, Candel M, Smit ES, de Vries H, Hoving C. The effectiveness of a Computer-Tailored e-learning program for practice nurses to improve their adherence to smoking cessation counseling guidelines: randomized controlled trial. *Journal of medical Internet research.* 2018;20(5):e193.
82. Moattari M, Moosavinasab E, Dabbaghmanesh MH, ZarifSanaiey N. Validating a Web-based Diabetes Education Program in continuing nursing education: knowledge and competency change and user perceptions on usability and quality. *Journal of Diabetes & Metabolic Disorders.* 2014;13(1):70.
83. Hugenholtz NI, Sluiter JK, Van Dijk FJ, Nieuwenhuijsen K. EBM E-learning: feasible and effective for occupational physicians in different countries. *Safety and health at work.* 2012;3(3):199-208.
84. Bos-Bonnie LH, van Bergen JE, Te Pas E, Kijser MA, van Dijk N. Effectiveness of an individual, online e-learning program about sexually transmitted infections: a prospective cohort study. *BMC family practice.* 2017;18(1):57.
85. Eide MJ, Asgari MM, Fletcher SW, et al. Effects on skills and practice from a web-based skin cancer course for primary care providers. *The Journal of the American Board of Family Medicine.* 2013;26(6):648-657.10.3122/jabfm.2013.06.130108
86. Ozturk E, van Iersel M, van Loon K, et al. Interactive online learning on perioperative management of elderly patients. *The American Journal of Surgery.* 2018;216(3):624-629.
87. Kerfoot BP, Kearney MC, Connelly D, Ritchey ML. Interactive spaced education to assess and improve knowledge of clinical practice guidelines: a randomized controlled trial. *Annals of surgery.* 2009;249(5):744-749.

88. Lombardi R, Ferreiro A, Rosa-Diez G, et al. Raising Awareness of Acute Kidney Injury: A Latin American Experience. *Kidney international reports.* 2018;3(6):1416-1423.
89. Nesterowicz K, Fereshtehnejad S-M, Edelbring S. e-Learning in Continuing Pharmacy Education is effective and just as accepted as on-site learning. *Pharmacy Education.* 2015;15(1):22 - 26.
90. Sinclair PM, Kable A, Levett-Jones T, Holder C, Oldmeadow CJ. The CKD-DETECT study: An RCT aimed at improving intention to initiate a kidney health check in Australian practice nurses. *Journal of clinical nursing.* 2019;28(15-16):2745-2759.
91. De Vries H. An integrated approach for understanding health behavior: The I-Change Model as an example. *Psychology and Behavioral Science International Journal.* 2017;2(2).
92. Eccles MP, Hrisos S, Francis J, et al. Do self- reported intentions predict clinicians' behaviour: a systematic review. *Implementation science : IS.* 2006;1:28-28.10.1186/1748-5908-1-28
93. Adams AS, Soumerai SB, Lomas J, Ross-Degnan D. Evidence of self-report bias in assessing adherence to guidelines. *Int J Qual Health Care.* 1999;11(3):187-192.10.1093/intqhc/11.3.187
94. Maue SK, Segal R, Kimberlin CL, Lipowski EE. Predicting physician guideline compliance: an assessment of motivators and perceived barriers. *Am J Manag Care.* 2004;10(6):383-391.
95. Kortteisto T, Kaila M, Komulainen J, Mäntyranta T, Rissanen P. Healthcare professionals' intentions to use clinical guidelines: a survey using the theory of planned behaviour. *Implementation Science.* 2010;5(1):51.
96. Sinclair PM, Levett-Jones T, Morris A, Carter B, Bennett PN, Kable A. High engagement, high quality: A guiding framework for developing empirically informed asynchronous e-learning programs for health professional educators. *Nursing & Health Sciences.* 2017;19(1):126-137.
97. Eccles M, Grimshaw J, Walker A, Johnston M, Pitts N. Changing the behavior of healthcare professionals: the use of theory in promoting the uptake of research findings. *Journal of clinical epidemiology.* 2005;58(2):107-112.
98. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *Bmj.* 2008;337.
99. Morrison LG. Theory-based strategies for enhancing the impact and usage of digital health behaviour change interventions: A review. *Digital Health.* 2015;1:2055207615595335.
100. Colquhoun HL, Squires JE, Kolehmainen N, Fraser C, Grimshaw JM. Methods for designing interventions to change healthcare professionals' behaviour: a systematic review. *Implementation Science.* 2017;12(1):30.10.1186/s13012-017-0560-5
101. McColl MA, Shortt S, Godwin M, et al. Models for integrating rehabilitation and primary care: a scoping study. *Archives of physical medicine and rehabilitation.* 2009;90(9):1523-1531.
102. Canadian Pharmacists Association. Pharmacists' scope of practice in Canada. https://www.pharmacists.ca/cpha-ca/assets/File/pharmacy-in-canada/Scope%20of%20Practice%20in%20Canada_JAN2016.pdf. Published January 2016. . Accessed Nov 11, 2019.
103. Tsuyuki RT, Houle SKD, Okada H. Time to give up on expanded scope of practice. *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2018;151(5):286-286.10.1177/1715163518793844
104. Weeks G, George J, Maclure K, Stewart D. Non-medical prescribing versus medical prescribing for acute and chronic disease management in primary and secondary care. *The Cochrane database of systematic reviews.* 2016;11:Cd011227.10.1002/14651858.CD011227.pub2
105. Tong EY, Roman C, Mitra B, et al. Partnered pharmacist charting on admission in the General Medical and Emergency Short-stay Unit - a cluster-randomised controlled trial in patients with complex medication regimens. *Journal of clinical pharmacy and therapeutics.* 2016;41(4):414-418.10.1111/jcpt.12405

106. Avery AJ, Rodgers S, Cantrill JA, et al. A pharmacist-led information technology intervention for medication errors (PINCER): a multicentre, cluster randomised, controlled trial and cost-effectiveness analysis. *Lancet (London, England).* 2012;379(9823):1310-1319.10.1016/s0140-6736(11)61817-5
107. Bootman JL, Harrison DL, Cox E. The health care cost of drug-related morbidity and mortality in nursing facilities. *Arch Intern Med.* 1997;157(18):2089-2096. Published 1997/10/24.
108. Currie K, Evans C, Mansell K, Perepelkin J, Jorgenson D. Community pharmacists' experiences with the Saskatchewan Medication Assessment Program. *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2019;152(3):193-203.10.1177/1715163519827980
109. Tsuyuki RT, Schindel TJ. Changing Pharmacy Practice: The Leadership Challenge. *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2008;141(3):174-180.10.3821/1913701x2008141174cpptlc20co2
110. A Killeen R. T What Will it Take to Make Patient-Centred Care a Reality? *Can Pharm J.* 2008;1 4 1 (4).
111. Makowsky MJ, Guirguis LM, Hughes CA, Sadowski CA, Yuksel N. Factors influencing pharmacists' adoption of prescribing: qualitative application of the diffusion of innovations theory. *Implementation Science.* 2013;8(1):109.
112. Teixeira B, Gregory PA, Austin Z. How are pharmacists in Ontario adapting to practice change? Results of a qualitative analysis using Kotter's change management model. *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2017;150(3):198-205.
113. Rosenthal MM, Austin Z, Tsuyuki RT. Barriers to pharmacy practice change:Is it our nature or nurture? *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2016;149(6):317-319.10.1177/1715163516672832
114. Foong EA-L, Grindrod KA, Houle SKD. Will I lose my license for that? A closer look at Canadian disciplinary hearings and what it means for pharmacists' practice to full scope. *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2018;151(5):332-344.10.1177/1715163518790773
115. Tsuyuki RT, Nakagawa RS. Regulation and innovation in practice – Not a "drug interaction"? *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2019;152(3):143-144.10.1177/1715163519839040
116. Rosenthal M, Austin Z, Tsuyuki RT. Are Pharmacists the Ultimate Barrier to Pharmacy Practice Change? *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2010;143(1):37-42.10.3821/1913-701X-143.1.37
117. Frankel GEC, Austin Z. Responsibility and confidence:Identifying barriers to advanced pharmacy practice. *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2013;146(3):155-161.10.1177/1715163513487309
118. Eccles M, Grimshaw J, Walker A, Johnston M, Pitts N. Changing the behavior of healthcare professionals: the use of theory in promoting the uptake of research findings. *Journal of clinical epidemiology.* 2005;58(2):107-112.10.1016/j.jclinepi.2004.09.002
119. Glanz K, Bishop DB. The Role of Behavioral Science Theory in Development and Implementation of Public Health Interventions. *Annual Review of Public Health.* 2010;31(1):399-418.10.1146/annurev.publhealth.012809.103604
120. Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker A. Making psychological theory useful for implementing evidence based practice: a consensus approach. *Qual Saf Health Care.* 2005;14(1):26-33.10.1136/qshc.2004.011155

121. Lawton R, Heyhoe J, Louch G, et al. Using the theoretical domains framework (TDF) to understand adherence to multiple evidence-based indicators in primary care: a qualitative study. *Implementation science.* 2015;11(1):1-16.
122. Francis JJ, Stockton C, Eccles MP, et al. Evidence-based selection of theories for designing behaviour change interventions: Using methods based on theoretical construct domains to understand clinicians' blood transfusion behaviour. *British journal of health psychology.* 2009;14(4):625-646.
123. Mazza D, Chapman A, Michie S. Barriers to the implementation of preconception care guidelines as perceived by general practitioners: a qualitative study. *BMC health services research.* 2013;13(1):36.
124. Curran JA, Brehaut J, Patey AM, Osmond M, Stiell I, Grimshaw JM. Understanding the Canadian adult CT head rule trial: use of the theoretical domains framework for process evaluation. *Implementation Science.* 2013;8(1):25.
125. Atkins L, Francis J, Islam R, et al. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implementation Science.* 2017;12(1):77.10.1186/s13012-017-0605-9
126. Mekonnen AB, McLachlan AJ, Brien JE, Mekonnen D, Abay Z. Barriers and facilitators to hospital pharmacists' engagement in medication safety activities: a qualitative study using the theoretical domains framework. *J Pharm Policy Pract.* 2018;11:2.10.1186/s40545-018-0129-y
127. Isenor JE, Minard LV, Stewart SA, et al. Identification of the relationship between barriers and facilitators of pharmacist prescribing and self-reported prescribing activity using the theoretical domains framework. *Res Social Adm Pharm.* 2018;14(8):784-791.10.1016/j.sapharm.2017.10.004
128. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine.* 2013;46(1):81-95.10.1007/s12160-013-9486-6
129. Michie S, Johnston M, Francis J, Hardeman W, Eccles M. From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied psychology.* 2008;57(4):660-680.
130. Atkins L, Francis J, Islam R, et al. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implementation Science.* 2017;12(1):1-18.
131. Edwards PJ, Roberts I, Clarke MJ, et al. Methods to increase response to postal and electronic questionnaires. *Cochrane Database of Systematic Reviews.* 2009(3).10.1002/14651858.MR000008.pub4
132. Thorpe C RB, McLean SL, Burt A, StewartM, Brown JB, Reid GJ, , S H. How to obtain excellent response rates when surveying physicians. Family Practice 2009; 26: 65–68. *Family Practice.* 2009;26:65-68.
133. Huijg JM, Gebhardt WA, Crone MR, Dusseldorp E, Presseau J. Discriminant content validity of a theoretical domains framework questionnaire for use in implementation research. *Implementation science : IS.* 2014;9:11-11.10.1186/1748-5908-9-11
134. Cane J, Richardson M, Johnston M, Ladha R, Michie S. From lists of behaviour change techniques (BCTs) to structured hierarchies: comparison of two methods of developing a hierarchy of BCTs. *Br J Health Psychol.* 2015;20(1):130-150.10.1111/bjhp.12102
135. Boone HN, Boone DA. Analyzing likert data. *Journal of extension.* 2012;50(2):1-5.

136. Patton DE, Ryan C, Hughes CM. Enhancing community pharmacists' provision of medication adherence support to older adults: A mixed methods study using the Theoretical Domains Framework. *Research in Social and Administrative Pharmacy.* 2020.
137. Kypri K, Stephenson S, Langley J. Assessment of Nonresponse Bias in an Internet Survey of Alcohol Use. *Alcoholism: Clinical and Experimental Research.* 2004;28(4):630-634.10.1097/01.Alc.0000121654.99277.26
138. Gale N, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC medical research methodology.* 2013:13:117.
139. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci.* 2012;7:37.10.1186/1748-5908-7-37
140. McLellan JM, O'Carroll RE, Cheyne H, Dombrowski SU. Investigating midwives' barriers and facilitators to multiple health promotion practice behaviours: a qualitative study using the theoretical domains framework. *Implementation Science.* 2019;14(1):64.10.1186/s13012-019-0913-3
141. Cahir C, Guinan E, Dombrowski SU, Sharp L, Bennett K. Identifying the determinants of adjuvant hormonal therapy medication taking behaviour in women with stages I–III breast cancer: a systematic review and meta-analysis. *Patient education and counseling.* 2015;98(12):1524-1539.
142. Amin MEK, Nørgaard LS, Cavaco AM, et al. Establishing trustworthiness and authenticity in qualitative pharmacy research. *Research in Social and Administrative Pharmacy.* 2020.
143. Michie S, Richardson M, Johnston M, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *Annals of Behavioral Medicine.* 2013;46(1):81-95.10.1007/s12160-013-9486-6
144. Courtenay M, Lim R, Deslandes R, et al. Theory-based electronic learning intervention to support appropriate antibiotic prescribing by nurses and pharmacists: intervention development and feasibility study protocol. *BMJ open.* 2019;9(8):e028326.10.1136/bmjopen-2018-028326
145. Ranji SR, Steinman MA, Shojania KG, Gonzales R. Interventions to reduce unnecessary antibiotic prescribing: a systematic review and quantitative analysis. *Medical care.* 2008:847-862.
146. Little P, Stuart B, Francis N, et al. Effects of internet-based training on antibiotic prescribing rates for acute respiratory-tract infections: a multinational, cluster, randomised, factorial, controlled trial. *The Lancet.* 2013;382(9899):1175-1182.
147. Chauhan BF, Jeyaraman M, Mann AS, et al. Behavior change interventions and policies influencing primary healthcare professionals' practice—an overview of reviews. *Implementation Science.* 2017;12(1):3.
148. Gregory PA, Teixeira B, Austin Z. What does it take to change practice? Perspectives of pharmacists in Ontario. *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2018;151(1):43-50.
149. Gregory PA, Austin Z. Conflict in community pharmacy practice: The experience of pharmacists, technicians and assistants. *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2017;150(1):32-41.
150. Austin Z, Gregory P. Learning Needs of Pharmacists for an Evolving Scope of Practice. *Pharmacy.* 2019;7(4):140.

151. Edwards DJ. Professional identity formation: A shared responsibility for academia and pharmacists. *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2020;153(1):18-20.
152. Gregory P, Austin Z. Pharmacists' lack of profession-hood: professional identity formation and its implications for practice. *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2019;152(4):251-256.
153. Kellar J, Lake J, Steenhof N, Austin Z. Professional identity in pharmacy: Opportunity, crisis or just another day at work? *Canadian Pharmacists Journal/Revue des Pharmaciens du Canada.* 2020;153(3):137-140.
154. Elvey R, Hassell K, Hall J. Who do you think you are? Pharmacists' perceptions of their professional identity. *Int J Pharm Pract.* 2013;21(5):322-332.10.1111/ijpp.12019
155. Hattingh L, Sim TF, Sunderland B, Czarniak P. Successful implementation and provision of enhanced and extended pharmacy services. *Res Social Adm Pharm.* 2020;16(4):464-474.10.1016/j.sapharm.2019.06.015
156. Dawodu P, Rutter P. How Do Pharmacists Construct, Facilitate and Consolidate Their Professional Identity? *Pharmacy (Basel).* 2016;4(3):23.10.3390/pharmacy4030023
157. Gregory P, Austin Z. Professional identity formation: The experience of regulated pharmacy technicians in Ontario. *Canadian Pharmacists Journal / Revue des Pharmaciens du Canada.* 2020;153(1):46-51.10.1177/1715163519882466
158. Biggs C, Hall J, Charrois TL. Professional abstinence: What does it mean for pharmacists? *Can Pharm J (Ott).* 2019;152(3):148-150.10.1177/1715163519840055
159. Gregory PA, Whyte B, Austin Z. How do community pharmacists make decisions? Results of an exploratory qualitative study in Ontario. *Can Pharm J (Ott).* 2016;149(2):90-98.10.1177/1715163515625656
160. Mickan S, Atherton H, Roberts NW, Heneghan C, Tilson JK. Use of handheld computers in clinical practice: a systematic review. *BMC Medical Informatics and Decision Making.* 2014;14(1):56.10.1186/1472-6947-14-56
161. Phillips CJ, Marshall AP, Chaves NJ, et al. Experiences of using the Theoretical Domains Framework across diverse clinical environments: a qualitative study. *J Multidiscip Healthc.* 2015;8:139-146.10.2147/JMDH.S78458
162. Ajzen I. The theory of planned behavior. *Organizational behavior and human decision processes.* 1991;50(2):179-211.
163. Taylor N, Parveen S, Robins V, Slater B, Lawton R. Development and initial validation of the Influences on Patient Safety Behaviours Questionnaire. *Implementation Science.* 2013;8(1):1-8.
164. (NAPRA) TNAoPRA. Pharmacy Technicians' Scope of Practice in Canadian Jurisdictions — Effective June 2019. https://www.napra.ca/sites/default/files/2019-09/Technician%20Scope%20of%20Practice%20-%20June%202019.pdf. Published 2019. Accessed.
165. Seyse S. Presidential Address: Do the Right Thing… Support Expansion of the Role of Pharmacy Technicians. *Journal of Pharmacy Practice.* 2016;29(1):87-89.
166. Gerretsen P, Pollock BG. Cognitive risks of anticholinergics in the elderly. *Aging Health.* 2013;9(2):159-166.
167. Gerretsen P, Pollock BG. Drugs with anticholinergic properties: a current perspective on use and safety. *Expert opinion on drug safety.* 2011;10(5):751-765.https://doi.org/10.1517/14740338.2011.579899

168. Kachru N, Carnahan RM, Johnson ML, Aparasu RR. Potentially inappropriate anticholinergic medication use in community-dwelling older adults: a national cross-sectional study. *Drugs & aging.* 2015;32(5):379-389.https://doi.org/10.1007/s40266-015-0257-x
169. Arseneau N, Braden K. Anticholinergic toxicity, polypharmacy, and inappropriate prescribing. *University of Western Ontario Medical Journal.* 2016;84(2):31-33.
170. Broderick ED, Metheny H, Crosby B. Anticholinergic Toxicity. *StatPearls [Internet].* 2020.
171. Green AR, Reifler LM, Bayliss EA, Weffald LA, Boyd CM. Drugs contributing to anticholinergic burden and risk of fall or fall-related injury among older adults with mild cognitive impairment, dementia and multiple chronic conditions: a retrospective cohort study. *Drugs & aging.* 2019;36(3):289-297.https://doi.org/10.1007/s40266-018-00630-z
172. Salahudeen MS, Duffull SB, Nishtala PS. Anticholinergic burden quantified by anticholinergic risk scales and adverse outcomes in older people: a systematic review. *BMC geriatrics.* 2015;15(1):1-14.https://doi.org/10.1186/s12877-015-0029-9
173. Nakham A, Myint PK, Bond CM, Newlands R, Loke YK, Cruickshank M. Interventions to reduce anticholinergic burden in adults aged 65 and older: a systematic review. *Journal of the American Medical Directors Association.* 2020;21(2):172-180. e175.https://doi.org/10.1016/j.jamda.2019.06.001
174. Moga DC, Abner EL, Rigsby DN, et al. Optimizing medication appropriateness in older adults: a randomized clinical interventional trial to decrease anticholinergic burden. *Alzheimer's research & therapy.* 2017;9(1):1-10.https://doi.org/10.1186/s13195-017-0263-9
175. Pitkälä KH, Juola A-L, Kautiainen H, et al. Education to reduce potentially harmful medication use among residents of assisted living facilities: a randomized controlled trial. *Journal of the American Medical Directors Association.* 2014;15(12):892-898.https://doi.org/10.1016/j.jamda.2014.04.002
176. Giguère A, Zomahoun HTV, Carmichael P-H, et al. Printed educational materials: effects on professional practice and healthcare outcomes. *Cochrane Database of Systematic Reviews.* 2020(8).ttps://doi.org/10.1002/14651858.CD004398.pub4
177. Kouladjian L, Chen TF, Gnjidic D, Hilmer SN. Education and assessment of pharmacists on the use of the drug burden index in older adults using a continuing professional development education method. *American journal of pharmaceutical education.* 2016;80(4).https://doi.org/10.5688/ajpe80463
178. Clifford RM, Ram PL, Lakos A, et al. Post-Registration Learning Trends of Community Pharmacists. *Journal of Pharmacy Practice and Research.* 2011;41(3):203-207. https://doi.org/10.1002/j.2055-2335.2011.tb00862.x
179. Hussein R, Lin EC, Grindrod K. Effects of computer-based education on health professionals' knowledge, skills, and behavior: A scoping review. *Journal of the American Pharmacists Association.* 2021;61(3):e44-e68. DOI: 10.1016/j.japh.2021.01.036
180. Seybert AL, Smithburger PL, Benedict NJ, Kobulinsky LR, Kane-Gill SL, Coons JC. Evidence for simulation in pharmacy education. *Journal of the American College of Clinical Pharmacy.* 2019;2(6):686-692.https://doi.org/10.1002/jac5.1167
181. Franic DM, Palmer R, Fulford M. Doctor of pharmacy student preferences for computer-based vs. paper-and-pencil testing in a, social and administrative pharmacy course. *Currents in Pharmacy Teaching and Learning.* 2021;13(7):819-825.https://doi.org/10.1016/j.cptl.2021.03.018
182. Mai C-W, Lee E-L, Wong P-S, Er H-M. Evaluation of Computer-based Simulation Learning on Knowledge, Learning Approaches and Motivation among Pharmacy Students. *Indian Journal of Pharmaceutical Education and Research.* 2019;53(4):595-602.DOI: 10.5530/ijper.53.4.120

183. O'Hare C, Girvin B. A Narrative Overview of the Effectiveness of E-learning in Pharmacy Education. *J Pharm Pract Pharm Sci.* 2018;1:09-23.
184. Eysenbach G, Group C-E. CONSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions. *Journal of medical Internet research.* 2011;13(4):e126.10.2196/jmir.1923
185. Thorpe C, Ryan B, McLean S, et al. How to obtain excellent response rates when surveying physicians. *Family practice.* 2009;26(1):65-68.https://doi.org/10.1093/fampra/cmn097
186. Magill N, Knight R, McCrone P, Ismail K, Landau S. A scoping review of the problems and solutions associated with contamination in trials of complex interventions in mental health. *BMC medical research methodology.* 2019;19(1):1-13.https://doi.org/10.1186/s12874-018-0646-z
187. Michie S, Van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation science.* 2011;6(1):1-12.https://doi.org/10.1186/1748-5908-6-42
188. Bareham J. ANTICHOLINERGICS: Reference List of Drugs with Potential Anticholinergic Effects. https://www.rxfiles.ca/RxFiles/uploads/documents/Psyc-anticholinergic-Ref%20List%20SPDP-complete.pdf. Published April 2020. Accessed April 2021.
189. Canada CoFPo. RxFiles. *Canadian Family Physician.* 2007;53(3):495-495.
190. IBM Corp. Released 2020. IBM SPSS Statistics for Windows V, 27.0, Armonk, NY: IBM Corp.
191. Case SM, Swanson DB. *Constructing written test questions for the basic and clinical sciences.* National Board of Medical Examiners Philadelphia, PA; 1998.
192. Zamanzadeh V, Ghahramanian A, Rassouli M, Abbaszadeh A, Alavi-Majd H, Nikanfar A-R. Design and implementation content validity study: development of an instrument for measuring patient-centered communication. *Journal of caring sciences.* 2015;4(2):165-178. doi: 10.15171/jcs.2015.017
193. Rodrigues IB, Adachi JD, Beattie KA, MacDermid JC. Development and validation of a new tool to measure the facilitators, barriers and preferences to exercise in people with osteoporosis. *BMC Musculoskeletal disorders.* 2017;18(1):1-9.https://doi.org/10.1186/s12891-017-1914-5
194. Streiner DL, Norman GR, Cairney J. *Health measurement scales: a practical guide to their development and use.* Oxford University Press, USA; 2015.
195. Kamarudin G, Penm J, Chaar B, Moles R. Educational interventions to improve prescribing competency: a systematic review. *BMJ open.* 2013;3(8):e003291.
196. Glanz K, Bishop DB. The role of behavioral science theory in development and implementation of public health interventions. *Annual review of public health.* 2010;31:399-418.https://doi.org/10.1146/annurev.publhealth.012809.103604
197. Stewart C, Gallacher K, Nakham A, et al. Barriers and facilitators to reducing anticholinergic burden: a qualitative systematic review. *International Journal of Clinical Pharmacy.* 2021(43):1451–1460.https://doi.org/10.1007/s11096-021-01293-4
198. Hussein R, Whaley CR, Lin EC, Grindrod K. Identifying barriers, facilitators and behaviour change techniques to the adoption of the full scope of pharmacy practice among pharmacy professionals: Using the Theoretical Domains Framework. *Research in Social and Administrative Pharmacy.* 2021;17(8):1396-1406.https://doi.org/10.1016/j.sapharm.2020.10.003
199. Maloney S, Haas R, Keating JL, et al. Breakeven, cost benefit, cost effectiveness, and willingness to pay for web-based versus face-to-face education delivery for health professionals. *Journal of medical Internet research.* 2012;14(2):e47.10.2196/jmir.2040
200. Levine DA, Funkhouser EM, Houston TK, et al. Improving Care After Myocardial Infarction Using a 2-Year Internet-Delivered Intervention: The Department of Veterans Affairs Myocardial

Infarction–Plus Cluster-Randomized Trial. *Archives of internal medicine.* 2011;171(21):1910-1917.10.1001/archinternmed.2011.498
201. Pannucci CJ, Wilkins EG. Identifying and avoiding bias in research. *Plastic and reconstructive surgery.* 2010;126(2):619.10.1097/PRS.0b013e3181de24bc
202. Murray E, Hekler EB, Andersson G, et al. Evaluating digital health interventions: key questions and approaches. In. Vol 51: Elsevier; 2016:843-851.
203. Hall CL, Sanderson C, Brown BJ, et al. Opportunities and challenges of delivering digital clinical trials: lessons learned from a randomised controlled trial of an online behavioural intervention for children and young people. *Trials.* 2020;21(1):1-13.
204. Walters SJ, dos Anjos Henriques-Cadby IB, Bortolami O, et al. Recruitment and retention of participants in randomised controlled trials: a review of trials funded and published by the United Kingdom Health Technology Assessment Programme. *BMJ open.* 2017;7(3):e015276.
205. Gillies K, Kearney A, Keenan C, et al. Strategies to improve retention in randomised trials. *Cochrane Database of Systematic Reviews.* 2021(3).10.1002/14651858.MR000032.pub3
206. Brueton V, Tierney J, Stenning S, et al. Strategies to improve retention in randomised trials: a Cochrane systematic review and meta-analysis. *BMJ open.* 2014;4(2):e003821.
207. Khadjesari Z, Murray E, Kalaitzaki E, et al. Impact and costs of incentives to reduce attrition in online trials: two randomized controlled trials. *Journal of medical Internet research.* 2011;13(1):e1523.
208. Keogh-Brown M, Bachmann M, Shepstone L, et al. Contamination in trials of educational interventions. 2007.
209. Sturges JE, Hanrahan KJ. Comparing telephone and face-to-face qualitative interviewing: a research note. *Qualitative research.* 2004;4(1):107-118.
210. Bandura A. Social cognitive theory: An agentic perspective. *Annual review of psychology.* 2001;52(1):1-26.
211. Carver CS, Scheier MF. Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. 1999.
212. Jarvill M, Kelly S, Krebs H. Effect of expert role modeling on skill performance in simulation. *Clinical Simulation in Nursing.* 2018;24:25-29.
213. Coram C. Expert role modeling effect on novice nursing students' clinical judgment. *Clinical simulation in nursing.* 2016;12(9):385-391.
214. Stander J, Grimmer K, Brink Y. Learning styles of physiotherapists: a systematic scoping review. *BMC Med Educ.* 2019;19(1):1-9.
215. Koohestani HR, Baghcheghi N. A comparison of learning styles of undergraduate health-care professional students at the beginning, middle, and end of the educational course over a 4-year study period (2015–2018). *Journal of education and health promotion.* 2020;9.

Appendices

Appendix A Search strategies for databases

Database	Search strategy	Number of results	Date of search
PubMed	(Education, Distance[mesh] OR “Distance Learning”[tiab] OR “Online Learning”[tiab] OR “Online Education”[tiab] OR “online continuing education”[tiab] OR online course*[tiab] OR “computer-based learning”[tiab] OR “digital learning"[tiab] OR "mobile learning"[tiab] OR “mobile education”[tiab] OR e-learning[tiab] OR elearning[tiab] OR mHealth[tiab] OR Online class*[tiab] OR “Internet-based class”[tiab] OR “Internet-based course”[tiab] OR “Electronic education”[tiab] OR Remote class*[tiab] OR “Web-based class”[tiab] OR “Web-based course”[tiab] OR “Web-based instruction”[tiab] OR Electronic workshop*[tiab] OR Distance course*[tiab] OR “Distance learning”[tiab] OR Computerized class*[tiab] OR Computerised class*[tiab] OR “Computer-mediated class”[tiab] OR “Computer-mediated instruction”[tiab] OR “Computer-assisted class”[tiab] OR “Computer-assisted instruction”[tiab] OR Virtual course*[tiab] OR “Virtual instruction”[tiab] OR E-instruction[tiab] OR E-education[tiab] OR “computer-based instruction”[tiab] OR Electronic class*[tiab]) AND (Pharmacists[mesh] OR Pharmacist*[tiab] OR Physicians[mesh] OR Nurses[mesh] OR physician*[tiab] OR doctor*[tiab] OR nurse*[tiab]) AND (behavior[mesh] OR behavior[tiab] OR behaviour[tiab] OR professional practice[mesh] OR practice*[tiab] OR skill*[tiab] OR knowledge[mesh] OR knowledge[tiab])	2,183	May 26, 2020
IPA	1 ("Distance Learning" or "Online Learning" or "Online Education" or "online continuing education" or online course* or "computer-based learning" or "digital learning" or "mobile learning" or "mobile education" or "e-learning" or "elearning" or "mHealth" or Online class* or "Internet-based class" or "Internet-based course" or "Electronic education" or Remote class* or "Web-based class" or "Web-based course" or "Web-based instruction" or Electronic workshop* or Distance course* or "Distance learning" or Computerized class* or Computerised class* or "Computer-mediated class" or "Computer-mediated instruction" or "Computer-assisted class" or "Computer-assisted instruction" or Virtual course* or "Virtual instruction" or "E-instruction" or "E-education" or "computer-based instruction" or Electronic class*).mp. [mp=title, subject heading word, registry word, abstract, trade name/generic name] (377)s 2 pharmacist*.mp. [mp=title, subject heading word, registry word, abstract, trade name/generic name] (54585) 3 nurse*.mp. [mp=title, subject heading word, registry word, abstract, trade name/generic name] (5989) 4 (physician* or doctor*).mp. [mp=title, subject heading word, registry word, abstract, trade name/generic name] (26316) 5 (knowledge* or practice* or behaviour* or behavior* or skill*).mp. [mp=title, subject heading word, registry word, abstract, trade name/generic name] (73845) 6 2 or 3 or 4 (72609) 7 1 and 5 and 6 (108)	108	May 27, 2020

EMBASE	1 ("Distance Learning" or "Online Learning" or "Online Education" or "online continuing education" or online course* or "computer-based learning" or "digital learning" or "mobile learning" or "mobile education" or "e-learning" or "elearning" or "mHealth" or Online class* or "Internet-based class" or "Internet-based course" or "Electronic education" or Remote class* or "Web-based class" or "Web-based course" or "Web-based instruction" or Electronic workshop* or Distance course* or "Distance learning" or Computerized class* or Computerised class* or "Computer-mediated class" or "Computer-mediated instruction" or "Computer-assisted class" or "Computer-assisted instruction" or Virtual course* or "Virtual instruction" or "E-instruction" or "E-education" or "computer-based instruction" or Electronic class*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (16037) 2 exp pharmacist/ (75931) 3 pharmacist*.ti,ab. (70254) 4 exp nurse/ (172428) 5 nurse*.ti,ab. (308515) 6 exp physician/ (729300) 7 physician*.ti,ab. (523974) 8 exp behavior/ (3870783) 9 behaviour*.ti,ab. (350677) 10 exp knowledge/ (163167) 11 knowledge*.ti,ab. (862140) 12 professional practice/ or clinical practice/ or good clinical practice/ or "scope of practice"/ or health care practice/ (349584) 13 exp skill/ (85140) 14 skill*.ti,ab. (256145) 15 2 or 3 or 4 or 5 or 6 or 7 (1394313) 16 8 or 9 or 10 or 11 or 12 or 13 or 14 (4970224) 17 1 and 15 and 16 (2702)	2,702	Jun 1, 2020
ERIC	("Distance Learning" OR "Online Learning" OR "Online Education" OR "online continuing education" OR online course* OR "computer-based learning" OR "digital learning" OR "mobile learning" OR "mobile education" OR "e-learning" OR "elearning" OR "mHealth" OR Online class* OR "Internet-based class" OR "Internet-based course" OR "Electronic education" OR Remote class* OR "Web-based class" OR "Web-based course" OR "Web-based instruction" OR Electronic workshop* OR Distance course* OR "Distance learning" OR Computerized class* OR Computerised class* OR "Computer-mediated class" OR "Computer-mediated instruction" OR "Computer-assisted class" OR "Computer-assisted instruction" OR Virtual course* OR "Virtual instruction" OR "E-instruction" OR "E-education" OR "computer-based instruction" OR Electronic class*) AND (pharmacist* OR physician* OR nurse* OR doctor*) AND (knowledge* OR practice* OR behaviour* OR behavior* OR skill*)	736	May 27, 2020
PsycINFO	**953** Results for (**Any Field**: "Distance Learning" *OR* **Any Field**: "Online Learning" *OR* **Any Field**: "Online Education" *OR* **Any Field**: "online continuing education" *OR* **Any Field**: "online course*" *OR* **Any Field**: "computer-based	953	May 28, 2020

	learning" *OR* **Any Field**: "digital learning" *OR* **Any Field**: "mobile learning" *OR* **Any Field**: "mobile education" *OR* **Any Field**: "e-learning" *OR* **Any Field**: "elearning" *OR* **Any Field**: "mHealth" *OR* **Any Field**: "Online class*" *OR* **Any Field**: "Internet-based class" *OR* **Any Field**: "Internet-based course" *OR* **Any Field**: "Electronic education" *OR* **Any Field**: "Remote class*" *OR* **Any Field**: "Web-based class" *OR* **Any Field**: "Web-based course" *OR* **Any Field**: "Web-based instruction" *OR* **Any Field**: "Electronic workshop*" *OR* **Any Field**: "Distance course*" *OR* **Any Field**: "Distance learning" *OR* **Any Field**: "Computerized class*" *OR* **Any Field**: "Computerised class*" *OR* **Any Field**: "Computer-mediated class" *OR* **Any Field**: "Computer-mediated instruction" *OR* **Any Field**: "Computer-assisted class" *OR* **Any Field**: "Computer-assisted instruction" *OR* **Any Field**: "Virtual course*" *OR* **Any Field**: "Virtual instruction" *OR* **Any Field**: "E-instruction" *OR* **Any Field**: "E-education" *OR* **Any Field**: "computer-based instruction" *OR* **Any Field**: "Electronic class*") *AND* (**Any Field**: pharmacist* *OR* **Any Field**: physician* *OR* **Any Field**: nurse* *OR* **Any Field**: doctor*) *AND* (**Any Field**: knowledge* *OR* **Any Field**: practice* *OR* **Any Field**: behaviour* *OR* **Any Field**: behavior* *OR* **Any Field**: skill*) *AND* **Language**: English		
CINHAL	S12 S1 AND S10 AND S11 S11 S2 OR S3 OR S4 OR S5 S10 S6 OR S7 OR S8 OR S9 S9 (MH "Behavior") or "behaviour" S8 "skills" OR (MH "Clinical Competence") S7 (MH "Practice Patterns") OR (MH "Medical Practice") OR (MH "Professional Practice, Theory-Based") OR "practice" S6 (MH "Knowledge") OR "Knowledge" OR (MH "Professional Knowledge") S5 MH "Nurses" S4 "doctor" S3 (MH "Physicians") S2 (MH "Pharmacists") OR "pharmacists" S1 "Distance Learning" OR “Online Learning” OR “Online Education” OR “online continuing education” OR online course* OR “computer-based learning” OR “digital-learning" OR "mobile learning" OR “mobile education” OR "e-learning" OR “elearning" OR "mHealth" OR Online class* OR “Internet-based class” OR “Internet-based course” OR “Electronic education” OR Remote class* OR “Web-based class” OR “Web-based course" OR “Web-based instruction" OR Electronic workshop* OR Distance course* OR "Distance learning" OR Computerized class* OR Computerised class* OR "Computer-mediated class" OR "Computer-mediated instruction" OR "Computer-assisted class" OR	331	May 29, 2020

"Computer-assisted instruction" OR Virtual course* OR "Virtual instruction" OR "E-instruction" OR "E-education" OR "computer-based instruction" OR Electronic class*

Appendix B Data extraction table for included studies

Study Title	Authors; Year; Country	Aim/Objective	Study Population	Study location	Methodology		Computer-Based Intervention (type, name, clinical content)	Features	Duration	Accreditation (Yes/No)	Theoretical Framework	Outcome Measures & Key Findings
					Study design	Intervention/ control group						
An evaluation of general practice nurses' knowledge of chronic kidney disease risk factors and screening practices following completion of a case study-based asynchronous e-learning module	Sinclair *et al*.; 2019; Australia	To evaluate (a) the effect of an asynchronous web-based e-learning module to develop GPNs' knowledge about CKD risk factors and screening practices; and (b) GPNs' perceived satisfaction with the e-learning module.	General practice nurses (GPNs)	Primary care setting	Randomized controlled trial	**Intervention:** tailored behavioural e-learning module (i.e. Module two) **Control:** knowledge-based active control e-learning module (i.e. Module one)	**Intervention type:** e-learning **Intervention name:** CKD DETECT **Clinical content:** CKD risk factors and evidence-based screening practices	Case studies, videos, assessment questions, pre-knowledge quiz, feedback, others (video transcripts, interactive links, multimedia, images and audio files)	N/A	No	Theory of planned behaviour (TPB) t- to assess nurses' intentions to initiate screening in people at risk of CKD.	**Demographics:** Mean age 47 years; 99% female. **a. Knowledge about CKD risk factors:** Assessed via 12-item scenario-based multiple-choice instrument; potential score range 1-12. The pre-test mean CKD knowledge scores were 3.77 out of 10 and mean post-test scores 5.48 out of 10. This indicated a significant

							improvement (mean difference 1.81, P < 0.01). However, overall scores remained inadequate. **b. Satisfaction with module:** Assessed via 30-item Learner Satisfaction with Asynchronous e-Learning (LSAe-L) instrument. Participants' global satisfaction mean score was 128.74 (s.d. 16.34) and mean sub-scale scores ranged from 8.32 (s.d. 1.3) to 26.01 (s.d. 4.3). The findings suggest that

												overall, participants were satisfied with how the module was developed. Note: data analysis did not compare study arms because groups completed the same module and there were no differences between groups.
Behavioural change in primary care professionals undertaking online education in dementia care in general practice	Bentley *et al*.; 2019; Australia	To describe and understand the effect of undertaking the Dementia Care Training and Education Program (DCTEP) on knowledge, confidence and	Practice nurses (PNs) and international medical graduates (IMGs)	Not found	Pre-post study	No control group (pre-post study design)	**Intervention type:** online **Intervention name:** Dementia Care Training and Education Program (DCTEP) **Clinical content:** diagnosis and management of patients with dementia	Videos, additional resources, discussion forum	3 hours (for all 4 modules)	No	N/A	**Demographics:** Of the 18 PNs, median age 45 years; 17 females and 1 male. Of the 15 IMGs: median age 40 years; 8 females and 7 males. **a. Dementia knowledge:**

	attitudes, and behavioural intentions of PNs and IMGs.			Assessed via Dementia Knowledge Assessment Scale (DKAS); score out of 50. Participants' knowledge about dementia increased after completing the modules. Baseline mean scores for the DKAS (out of 50) were 39.7 for IMGs and 34.1 for PNs. DKAS mean scores increased by 10% to 43.7 for IMGs and by 28% to 43.6 for PNs. **b. Dementia confidence and attitudes:**

Assessed via Confidence and Attitudes Towards Dementia measure (GPACS-D); score out of 15. Participants' confidence and attitudes about dementia increased after completing the modules. Baseline mean scores for the GPACS-D (out of 15) were 11.1 for IMGs and 11.2 for PNs. GPACS-D mean scores increased by 18%to 13.1 for IMGs and by 16% to 13.0 for PNs.

						c. Behavioural intentions: Assessed via 12-item continuing professional development (CPD) reaction questionnaire. Participants had strong intentions to apply a systematic framework to identify and manage dementia. **d. Experience of working with people with dementia in light of online modules:** Assessed via pre- and 1 month post-module semi-structured interviews. In post-module

						interviews, participants reported increased awareness, knowledge and confidence in assessing and managing people with dementia, corroborating the questionnaire results (questionnaire evaluates beliefs about consequences, social influence, moral norm, beliefs about capabilities, and intention). Overall, this project has demonstrated some early changes in clinical behaviour around

												dementia care in general practice.
The Effectiveness of a Computer-Tailored E-Learning Program for Practice Nurses to Improve Their Adherence to Smoking Cessation Counseling Guidelines: Randomized Controlled Trial	de Ruijter *et al*.; 2018; the Netherlands	To assess the effects of the CT (computer-tailored) e-learning program on PNs' smoking cessation guideline adherence in a randomized controlled trial (RCT). (Hypothesis: PNs' guideline adherence would significantly improve as a result of exposure to the CT e-learning program.)	Practice nurses (PNs)	Across the Netherlands	Randomized controlled trial	**Intervention group:** e-learning modules with tailored feedback letters **Control group:** general modules	**Intervention type:** web-based **Intervention name:** N/A **Clinical content:** smoking cessation guidelines (for both e-learning modules and general modules). However, e-learning modules had content tailored to characteristics previously demonstrated to be effective in achieving behavior change	Additional resources, discussion forum, feedback	6 months	No	I-Change Model (ICM) – to develop module content and assess nurses' guideline adherence	**Demographics:** Mean age of overall sample 47.3 years; 97.8% female. **a. Overall guideline adherence:** Assessed via mixed linear and logistic regression analyses. Mixed linear regression analysis revealed that counseling experience moderated the program's effect on PNs' overall guideline adherence (beta=.589; 95% CI 0.111-1.068;

PHolm-Bonferroni =.048), indicating a positive program effect on adherence for PNs with a more than average level of counseling experience.

b. Step-based guideline adherence: Assessed via mixed linear and logistic regression analyses; measurement also involved questions concerning the 9 evidence-based counseling steps. Mixed logistic regression analyses regarding

						adherence to individual guideline steps revealed a trend toward moderating effects of baseline levels of behavioral predictors and counseling experience. More specifically, for PNs with less favorable scores on behavioral predictors (eg, low baseline self-efficacy) and high levels of counseling experience, the program significantly increased adherence. **c. Predictors**

							of guideline adherence: i.e. i) Intention to use a smoking cessation guideline; ii) Knowledge of evidence-based smoking cessation guidelines; iii) Level of self-efficacy; iv) Intention to make action plans; v) Intention to make coping plans - via 10 Y/N items. Missing detailed results for predictors. As per above: PNs with less favorable scores on behavioral predictors (eg, low baseline

												self-efficacy) and high levels of counseling experience, the program significantly increased adherence.
Raising Awareness of Acute Kidney Injury: A Latin American Experience	Lombardi *et al*.; 2018; Latin America (Uruguay)	To describe the design, implementation, and results of these courses and to evaluate its impact on medical knowledge.	Nephrologists (for Course 1) and PCPs (for Course 2)	Hospitals across the Latin American region	Pre-post study	Not found	**Intervention type:** online / distance (for both Course 1 and Course 2) **Intervention name:** N/A **Clinical content:** acute kidney injury (for both Course 1 and Course 2)	Case studies, videos, additional resources, certificate of completion, discussion forum, assessment questions, feedback, others (electronic rounds, videoconferences)	***Course 1:*** 30 hours over 7 weeks ***Course 2:*** 4 weeks	No	N/A	**Demographics:** For Course 1 (Nephrologists): 46% were <35 years of age; 52% male. For Course 2 (PCPs): no age data; 61% female. ***Course 1:*** **a. Knowledge gain:** Assessed via 10-question test before and after course completion. The pretest and posttest were completed by 355 participants.

						The mean number of right answers was 5.87 and 8.01, respectively ($P < 0.05$), which can be considered as a gain knowledge equivalent to 36%. **b. Effect of course on clinical practice:** Assessed via commitment to change statement at the end of course. Missing results for effect of course on clinical practice. **c. Satisfaction :** Assessed via satisfaction survey.

					The platform was considered user-friendly by 80% of the participants. Overall, 28% of the participants experienced no limitations. Clinical simulation was considered the best part and lack of time the main limitation for learning. ***Course 2:*** **a. Satisfaction :** Assessed via satisfaction survey. Of the 121 participants that answered the satisfaction survey, 118 were

												satisfied or very satisfied. As with Course 1, clinical simulation was considered the best part and lack of time the main limitation for learning. No mention of measurement of changes in knowledge, skills, or behaviour for Course 2.
Interactive online learning on perioperative management of elderly patients	Ozturk *et al*.; 2018; the Netherlands	To evaluate the execution of the course and the short term effects regarding knowledge, attitude, and confidence in order to assess its usefulness as an educational	Medical healthcare workers involved in surgery in the elderly	The Netherlands	Pre-post study / before-and-after comparative intervention study	No control group	**Intervention type:** online **Intervention name:** N/A **Clinical content:** perioperative management of the elderly patient, e.g. frailty, cognitive disorders, functional decline, polypharmacy	Case studies, videos, discussion forum, assessment questions, others (weekly emails with tips and extra learning goals)	6 weeks (4 hours per week)	Yes – 10 CME points	N/A	**Demographics:** Mean age 35; 66% female **a. Knowledge:** Assessed via pre and post knowledge tests (multiple-choice); full score 100%.

	tool in geriatric education.		and shared decision making	Knowledge scores improved significantly from 49% to 65% ($p < 0.005$). **b. Attitude:** Assessed via modified Aging Semantic Differential (ASD) with 27 items. A better attitude correlated with a higher total knowledge score in surgeons and surgical residents ($p = 0.02$). **c. Self-perceived confidence:** Assessed via needs assessment questionnaire with 18 questions. Participants felt more secure ($p < 0.005$) in

												the treatment of the older patient at the end of the course. Therefore: self-perceived confidence in treating the older patient with regard to the topics improved significantly throughout the course, with a large effect size (Cohens D > 0.8).
Impact of online toxicology training on health professionals: the Global Educational Toxicology Uniting Project (GETUP)	Wong *et al*.; 2017; Australia	To investigate whether an online toxicology course could improve the knowledge of health professionals treating poisoned patients in developing and developed	Health professionals - emergency doctors, medical officers, physicians, pharmacists, poisons information specialists, toxicologi	Across 33 countries	Pre-post study	Not found	**Intervention type:** online **Intervention name:** The Global Educational Toxicology Uniting Project (GETUP) **Clinical content:** toxicology and management of poisonings	Case studies, additional resources, discussion forum	Not found	No	N/A	**Demographics:** Median age 34 years; 54% male **a. Difference in MCQ score pre- and post-modules (primary):** Assessed via 80 MCQs administered before and

	countries worldwide.	sts, medical students, nurses)				after each module. Overall median pre-module MCQ scores were 56% (95%CI: 38, 75%) compared to post-module MCQ scores median 89% (95% CI: 67, 100%) ($p < .0001$). **b. Final quiz scores (i.e. knowledge retention) (secondary):** Assessed via final quiz with 30 MCQs covering all modules. There was an overall improvement in the median pre-module MCQ score compared to the final quiz score of 86%

						(IQR: 76, 92%) (p < .0001). **c. Number of participants who felt course changed their clinical practice and rating of modules (secondary):** Assessed via feedback survey with questions and 5-point Likert scale (1 = poor, 5 = excellent). At the time of survey, one month post-cessation of the course, 66 (65%) of the responders had thought the course had changed their clinical practice so far and 35

												(35%) did not.
Effectiveness of an individual, online e-learning program about sexually transmitted infections: a prospective cohort study	Bos-Bonnie *et al*.; 2017; the Netherlands	To evaluate if the individual, online e-learning module "The STI-consultation", using the CtC-method, has a lasting, positive effect on the knowledge, attitude, and behavior of GP's concerning the STI-consultation.	General practitioners (GPs)	Across the Netherlands	Prospective cohort study	No control group	**Intervention type:** online / e-learning **Intervention name:** The STI-consultation **Clinical content:** sexually transmitted infections (STIs)	Case studies, videos, follow-up questions, others (email reminders of participants' intended practice changes)	2 hours	Yes	N/A	**Demographics:** Mean age 38.9 years; 66.4% female. **a. Knowledge and attitudes toward STI:** Assessed via 11-question quickscan (answers given on 4-point Likert scale (1 = does not apply, 4 = very applicable)). The knowledge and attitude of the participants improved, which persisted up to two years after completing the program. Participants

							showed a statistically significant increase on 5 of the 11 questions. There were no significant differences present between participants who completed the e-learning program less than one year ago and participants who completed the e-learning program more than one year ago (data not shown). **b. Changes in clinical practice (i.e. behaviour toward STI):** Assessed via

												comparison of intended changes immediately after program and extent of implementation of intended changes 2 years after program. Participants that formulated intended changes, reported that 34.3% of the intended changes was fully implemented, 62.9% was partially implemented, and 2.8% was not implemented.
e-Learning in Continuing Pharmacy	Nesterowicz *et al*.; 2015; Poland	To compare remote courses to on-site courses based on	Pharmacists	The study population represented pharmacists from community	Pre-post study	**Intervention group:** remote course **Control group:** on-	**Intervention type:** e-learning **Intervention name:** Proper Monitoring of	Discussion forum, feedback	6 months	No	N/A	**Demographics:** For intervention group: average age 39 years;

Education is effective and just as accepted as on-site learning	knowledge change and level of acceptance.	and hospital pharmacies and those who worked at faculties of pharmacy and pharmaceutical wholesales.	site course taught convention ally (Same content and communication amongst one another and with a tutor allowed for both groups)	Blood Pressure and Chosen Laboratory Parameters Important for Patients with Hypertension **Clinical content:** hypertension/blood pressure monitoring		more women than men. For control group: average age 45 years; more women than men. **a. Knowledge changes and/or increase:** Assessed via knowledge test with 15 MCQs before and after course; score out of 15. The mean of the knowledge score in pre-test was 9.5 (SD=2.0) and 9.6 (SD=2.6) among the intervention and control group, respectively ; no significant difference

	was observed (Mann-Whitney U: Z value= -0.314, p=0.753). The increase of knowledge within each group before and after the course was significant (Wilcoxon Rank: Control group: Z value= -11.12, p<0.001; Intervention group: Z value= -19.32, p<0.001). However, the groups did not differ significantly in change of knowledge. The mean percentage of total changes in knowledge

					score was 29.0% (SD=16.4) and 27.2% (SD=19.2) in intervention and control groups, respectively. **b. Level of acceptance:** Assessed via acceptance questionnaire. There were 91% of respondents from the intervention group and 87% from the control group who liked their course. There were 91% from the intervention group and 94% from the control one who thought that such courses

												were effective. The most valued aspect in both groups was the subject of the course.
Effects of an online problem-based learning program on sexual health care competencies among oncology nurses: A pilot study	Kim and Shin; 2014; Korea	To test the effectiveness of an online problem-based learning (e-PBL) program that offers multimedia scenarios to develop sexual health care competencies	Oncology nurses (RNs)	Tertiary hospital in Jeonju, Korea	Pretest-posttest randomized control group trial	**Intervention group:** received e-PBL program **Control group:** did not receive e-PBL program or any additional education	**Intervention type:** e-PBL / online PBL **Intervention name:** N/A **Clinical content:** sexual health care (SHC) scenarios applying PBL *(PBL = problem-based learning)*	Case studies, videos, additional resources, discussion forum, assessment questions, others (chat, file downloading and uploading tools, bulletin-board system)	8 weeks (1 week per tutorial), where each tutorial took 1-2 hours to complete	No	N/A	**Demographics:** Mean age of total sample 33.66 years; no gender data. **a. SHC knowledge (primary):** Assessed via 33-item Sexual Health Care Knowledge Scale. Nurses in the intervention group scored significantly higher on knowledge than did those in the control group. **b. SHC attitudes (primary):**

							Assessed via 17-item Sexual Health Care Attitude Scale. The intervention group exhibited no significant differences in attitude following the intervention. **c. SHC practice (primary):** Assessed via 21-item Sexual Health Care Practice Scale. The intervention group exhibited no significant differences in practices following the intervention. **d. Feasibility**

												(secondary): Assessed via questionnaire. Results of the evaluation questionnaire showed that 52.9% of participants indicated they were satisfied with e-PBL in general, and 47.1% indicated they were neither satisfied nor dissatisfied.
Can an e-learning course improve nursing care for older people at risk of delirium: a stepped wedge cluster randomised trial	van de Steeg *et al*.; 2014; the Netherlands	To investigate whether offering nursing staff an e-learning course in delirium care increased the adherence to the Frail Elderly	Hospital nursing staff	2 wards in 18 Dutch hospitals	Stepped wedge cluster randomised trial	No control group (stepped wedged design where participating hospitals crossed over from the control to intervention phase)	**Intervention type:** e-learning **Intervention name:** N/A **Clinical content:** delirium clinical features, risk factors, diagnostics, prevention, and treatment	Case studies, certificate of completion, assessment questions	4 hours to finish course and knowledge test; access to course available for 3 months	No	N/A	**Demographics:** Mean age 35.7 years; 6.7% male. **a. % of older patients screened for delirium risk (primary):** Assessed via delirium

	Project (FEP) guideline, as well as the impact of the course on nurses' knowledge of delirium.			risk screening rate, number of nursing interventions received by at-risk patients, and use of the Delirium Observation Screening (DOS) scale in at-risk patients. The e-learning course on delirium had a significant positive effect on the risk screening of older patients by nursing staff (OR 1.8, p-value <0.01), as well as on other aspects of delirium care. The number of patients diagnosed with

						delirium was reduced from 11.2% in the control phase to 8.7% in the intervention phase (p = 0.04). **b. Changes in delirium knowledge (secondary):** Assessed via knowledge test before and after course; full score 100%. The e-learning course also showed a significant positive effect on nurses' knowledge of delirium. (The corrected average score for the first knowledge test was 79.6% (CI

												78.9 to 80.4), compared to 88.6% (CI 88.0 to 89.2) for the second test.
Validating a Web-based Diabetes Education Program in continuing nursing education: knowledge and competency change and user perceptions on usability and quality	Moattari *et al*.; 2014; Iran	To validate a web-based diabetes education program through measurement of nurses' knowledge and clinical competency in [type 1 and type 2] diabetes and nurses' perception about its usability and quality	Licensed nurses	five teaching hospitals	Single group quasi-experimental study with pre- and post-tests	Not found	**Intervention type:** web-based (provided via Learning Management system (LMS)) **Intervention name:** N/A **Clinical content:** diabetes and diabetes complications classification and management	Videos, additional resources, discussion forum, assessment questions, feedback, others (animated slides, images, video sequences, forms, tables and charts with synchronized narrations, ability to send/receive messages, display of online status)	60 days (5 days per module; 12 modules total)	No	N/A	**Demographics:** Mean age 36.3 years; 100% female **a. Diabetes knowledge:** Assessed via 125-MCQ knowledge test; score out of 24. The mean baseline diabetes knowledge score was 11.26 ± 0.834 from 24. This increased to 17.47 ± 0.607 after Web-based education ($p < 0.001$). Results of paired t-tests in all modules, except the

							foot ulcers module, showed significant changes in knowledge scores. **b. Diabetes competency :** Assessed via 10-station OSCE; score out of 20. Nurses' competency score prior to Web-based education was 9.13 ± 1.60 from 20 which increased to 15.27 ± 1.50 after intervention ($p < 0.001$). **c. Program usability:** Assessed via 35-item questionnaire. Overall assessment of course variable had

												the highest mean rating and the computer use variable was the lowest rated among usability variables.. **d. Program quality:** Assessed via 49-item questionnaire. For quality variables, the highest mean rating was self-assessment and the ability to learn and the accessibility variables were the lowest.
A randomized clinical trial of a web-based tobacco cessation education program	Gordon *et al*.; 2013; United States	*Hypothesis*: RTs, RNs, and NPs who participated in the WeBREATHe program would show increases in	Practicing pediatric respiratory therapists (RTs), registered nurses (RNs), and nurse	Children's Hospital of Philadelphia and The Children's Hospital of University of Colorado at Denver	Randomized clinical trial	**Intervention:** immediate access to WeBREATHe **Control:** delayed access to WeBREAT	**Intervention type:** web-based **Intervention name:** Web-Based Respiratory Education About Tobacco and	Case studies, videos, additional resources, certificate of completion, discussion forum, assessment questions	At least 3 hours over the course of 1 week	Yes – 3 continuing education units (CEUs)	N/A	**Demographics:** Mean age 36 years; 88.3% female. 90 (85.7%) participants took the CE test; 75

	their tobacco cessation intervention behaviors, positive attitudes, and self-efficacy in providing tobacco cessation interventions to their patients' parents, and decreases in their perceived barriers to providing these interventions.	practitioners (NPs)		He (i.e. after completion of the final assessment)	Health (WeBREATHe) **Clinical content:** tobacco cessation education	(71.4%) participants passed the CE test. **a. Knowledge about program material:** Assessed via 10 items. Missing results for knowledge. **b. Behaviours:** Assessed via 15 items on the "5 As". Participants in the training condition were more likely to increase their tobacco cessation intervention behaviors than their delayed training counterparts (F[1, 213] = 32.03, P <

					.001). Training participants showed significantly greater levels of each of the "5 As", particularly assist/arrange (F[1, 213] = 35.52, P < .001). **c. Previous training:** Assessed via 1 question. Missing results for previous training. **d. Attitudes:** Assessed via 9 items. Participants in the training condition reported a greater increase in positive attitudes (F[1, 213] = 27.90, P < .001; h2 = 0.116).

							e. Perceived barriers: Assessed via 7 items. Participants in the training condition reported a greater decrease in perceived barriers (F[1, 213] = 31.46, P < .001; h2 = 0.129). **f. Self-efficacy:** Assessed via 6 items. Participants in the training condition reported a greater increase in self-efficacy toward providing tobacco cessation interventions (F[1, 213] = 42.89, P < .001; h2 = 0.168).

												g. Satisfaction with program: Assessed via 10 items. Participants in the training condition rated the program highly on measures of consumer satisfaction. Note: all items measured using 5-point scale (1 = strongly disagree/never, 5 = strongly agree/always).
Can emergency nurses' triage skills be improved by online learning? Results of an	Rankin *et al*.; 2013; Canada	To determine the impact of Web learning/3 changes to "standard" Web course on RNs' use of the	Registered nurses (RNs) in ED	6 hospitals across Canada	Randomized trial	**Intervention group:** 1) mandatory tutorial, 2) marks for online discussion, 3) triage workplace project	**Intervention type:** online **Intervention name:** N/A **Clinical content:** the Canadian Triage and Acuity Scale (CTAS)	Online discussion forum supported by a course facilitator, case studies	6 weeks	No	N/A	**a. Demographic information:** Assessed via 21-item questionnaire called Learner

experimen t	Canadian Triage and Acuity Scale (CTAS), i.e. on the accuracy of the triage skills of registered nurses (RNs). *Null hypothesis:* There will be no difference in satisfaction with Web-based learning and CTAS triage accuracy between the RNs in the control (C) group compared with the RNs in the experimenta l (E) group.	**Control group:** 1) tutorial recommend ed but not required, 2) no marks for online discussion, 3) no workplace project (Same content and learning activities for both groups)	Demographi c Survey (LDS). Majority of respondents were women aged between 35-54 years. **b. Participant experiences :** Assessed via interviews at end of course and 52-item self-report instrument called Online Learner Support Instrument (OLSI). The mean for the total OLSI score for the E group was 124.41 (SD, 17.3), or 75.4 of 100, and the mean for the C group was 123.37 (SD,

						17.8), or 74.7 of 100. There were no statistically significant differences in total OLSI scores (P = .33) or any of the subscale scores between the E and C groups. **c. Changes in clinical practice:** Assessed chart audit tool (which assessed accuracy of nurses' CTAS triage scores) and audit of online discussion. Out of the 367 charts audited, 69.8% (n = 256) were identified as correctly triaged by the

												emergency nurse expert. The accuracy rate [of triage] was 72.1% (n = 132) for the E group and 67.3% (n = 124) for the C group. Although [the authors] believe this difference to be clinically significant, a Fisher exact test showed that the difference was not statistically significant (P = .36).
Effects on skills and practice from a web-based skin cancer course for primary care providers	Eide *et al*.; 2013; United States	To develop an interactive web-based course to improve the skills of practicing PCPs in skin cancer detection	Primary care providers (PCPs)	9 practices in 2 health maintenance organizations	Before-and-after study	**Intervention group:** case-based format with case vignettes **Control group:** traditional textbook format	**Intervention type:** web-based **Intervention name:** Internet Curriculum for Melanoma Early Detection (INFORMED)	Case studies, assessment questions, feedback, others (clinical images)	1-2 hours	Yes – 2 hours credit	N/A	**Demographics:** Mean age 50.5 years and ranged from 30 to 68 years; 54% female. **a. Competence (i.e.**

	(emphasizing melanoma), to evaluate the course's effect on the abilities of PCPs to diagnose and manage skin lesions suspicious for melanoma and nonmelanoma skin cancer, and to assess the course's potential effect on PCP practices.		(Both formats contained same topics) Note: Participants were able to choose one of the 2 learning formats	**Clinical content:** skin cancers (melanoma, basal cell carcinoma (BCC), and squamous cell carcinoma (SCC)), benign lesions, and differential diagnoses	**"skills") and performance:** Assessed via test of 25 images of lesions administered before, immediately after, and 6 months after course on 3 major categories: overall score, diagnosis score, and management (refer or reassure) score. For all 3 major categories, immediate posttest scores were significantly higher than pretest scores. The mean score for appropriate diagnosis and managemen

t increased from 36.1% to 46.7% (odds ratio, 1.6; 95% confidence interval, 1.4 –1.9), with greatest improvement in benign lesions, from 32.1% to 46.3% (odds ratio, 1.9; 95% confidence interval, 1.6 –2.4). Dermatology referrals [i.e. management] for suspicious lesions or new visits by participants' patients decreased at both sites after the course (from 630 to 607 and from 726 to 266, respectively). Scores for

					the 6-month posttest declined from those of the immediate posttest but in general remained higher than pretest scores. **b. Attitudes, confidence, and assessment of course:** Assessed via 5-point Likert scale (5 = high agreement) asked before, immediately after, and 6 months after course. Participants' attitudes and confidence improved modestly after the course (<1 point on a 5-point Likert

						scale). No data on assessment of course. **c. Effect of course on clinical performance:** Assessed via comparison between participants' patient panels (which contained number of patient skin biopsies and skin cancer diagnoses) 1 year before course (late 2010) and 6 months after course (late 2011). At site A, there was a slight decrease in referrals for possible skin cancer to dermatology (from 630 to 607) in the

						6 months after the course compared with the same period 1 year earlier. At site B, the number of new patient visits seen in dermatology from participants' panels decreased substantially (from 727 to 266), despite an increase in new visits to dermatology system wide (from 8202 to 9624). Skin biopsy rate and skin cancer diagnoses were comparable in 2010 and 2011 at both sites. Therefore, there was no increase in

												dermatology utilization for suspicious lesions after the skin cancer training.
EBM E-learning: Feasible and Effective for Occupational Physicians in Different Countries	Hugenholtz *et al*.; 2012; the Netherlands	To design electronic EBM course, and to study the feasibility and utility of the course as well as its effectiveness in increasing EBM knowledge, skills, and behaviour.	Occupational physicians (OPs)	Education/training centers in 16 countries	Within-subjects study with pre- and post-test evaluation	No control group (a reported limitation of the study)	**Intervention type:** e-learning **Intervention name:** N/A **Clinical content:** EBM topics	Additional resources, feedback, others (assignments, help files)	1.5 hours	No	N/A	**Demographics:** 60% <40 years; 50% female. **a. EBM knowledge:** Assessed via 31 T/F/don't know questions; standardized score range 0-100. The electronic EBM course has an overall significant effect on the OPs' knowledge of EBM and their self-efficacy on practising it ($p < 0.01$ and $p = 0.02$, respectively).

							b. EBM skills: Assessed via test with 8 open questions; standardized score range 0-100. The overall effect of the intervention on the enhancement of EBM skills is not significant, but the skills enhance substantially at T1 and, although they decline, are still higher at T2 compared to T0. **c. EBM attitude, behaviour, and determinants of behaviour:** Assessed via 22 statements; standardized

							score range 0-100. The initial high scores on attitude remain stable over time. No significant effect was found on EBM behaviour and determinants of behaviour. **d. Evidence use:** Assessed via reporting of 4 categories (e.g. number of hours spent on solving a specific case and on keeping up-to-date over the previous month). After the course, more OPs use the international journals to solve a case.

												e. Feasibility and utility of course: Assessed via 14 statements for agreement on 4-point Likert scale (1 = strongly disagree, 4 = strongly agree). The vast majority of the OPs agree with the positive statements on the utility and feasibility of the course.
Effects of online palliative care training on knowledge, attitude and satisfaction of primary	Pelayo *et al*.; 2011; Spain	To measure the effectiveness of an online educational model regarding knowledge, attitude towards palliative care, and	Primary care providers (PCPs)	Primary care centers throughout Spain	Randomized controlled educational trial	**Intervention group:** had access to online program for PC self-training **Control group:** no access to the online program, but could	**Intervention type:** online / e-learning (Moodle) **Intervention name:** N/A **Clinical content:** palliative care management	Videos, discussion forum, assessment questions, feedback, others (images, diagrams, interactive webpages)	96 hours	Yes – 15 credits	N/A	**Demographics:** For intervention group: mean age 48; 44% female. For control group: mean age 47; 46% female.

care physicians	physician's satisfaction in comparison with a control group.	voluntarily receive traditional training (i.e. the usual PC training offered in working area)			**a. Palliative care knowledge** Assessed via 33-item questionnaire with single correct answer. There were significant differences in favor of the intervention group in terms of knowledge (mean 4.6; CI 95%: 2.8 to 6.5 (p = 0.0001), scale range 0-33). **b. Palliative care attitude:** Assessed via questionnaire with 5-point Likert scale answers on confidence in symptom management and

						communication. There were significant differences in favor of the intervention group, in terms of confidence in symptom management (p = 0.02) and confidence in terms of communication (p = 0.038). **c. Satisfaction:** Assessed via satisfaction questionnaire and Moodle evaluation questionnaire. The satisfaction of the intervention group was high.

Interactive spaced education to assess and improve knowledge of clinical practice guidelines: a randomized controlled trial	Kerfoot *et al*.; 2009; United States	To investigate whether ISE (Interactive Spaced Education) could significantly improve the CPG knowledge of urology residents and practicing urologists, and to determine whether ISE is an acceptable form of graduate and continuing medical education (GME/CME).	Urologists and urology residents	Throughout the United States	Randomized controlled trial	**Intervention group:** had completed 2 cycles for ISE program at time of presenting cycle 3 (intervention group is split into cohort A and B) **Control group:** presented with material for the first time at time of presenting cycle 3	**Intervention type:** online (specifically, Interactive Spaced Education (ISE)) **Intervention name:** N/A **Clinical content:** urology topics, specifically hematuria and priapism (HP) and staghorn calculi, infertility, and antibiotic use (SIA)	Case studies, assessment questions, feedback	20 weeks (content was repeated 3 times over 20 weeks)	No	N/A	**Demographics:** Mean age 47; majority male **a. CPG knowledge difference (primary):** Assessed via comparison of learning gains of physicians who completed 2 cycles of ISE course to knowledge of physicians presented with material for first time (controls); full score 100%. During the ISE course, cohort A scores (on hematuria and priapism CPGs) increased from a mean

44.9% (SD, 14.9) in cycle 1 to 74.0% (SD, 15.0) in cycle 2 and 75.7% (SD, 13.7) in cycle 3. Similarly, cohort B scores (on staghorn calculi, infertility, and antibiotic prophylaxis CPGs) increased from a mean 45.2% (SD, 12.9) in cycle 1 to 65.5% (SD, 14.6) in cycle 2 and to 69.5% (SD, 11.4) in cycle3. Compared with cycle 3 control scores (48.2%, SD: 12.6), the ISE course on HP generated a 27.5%

						absolute score increase and a 57% relative score increase (P < 0.001), corresponding to a Cohen effect size of 2.2. Compared with cycle 3 control scores (44.6%, SD: 11.5), the ISE course on S-I-A generated a 24.9% absolute score increase and 56% relative score increase (P < 0.001). **b. Intention-to-treat analysis of CPG knowledge difference (secondary):**

						Included all 480 participants, whether or not they completed the program. Significant gains in knowledge were also demonstrated in the intention-to-treat analysis, with Cohen effect sizes of 1.54 and 0.75 for cohorts A and B, respectively (both P < 0.001). **c. Baseline CPG knowledge levels of physicians on all ISE items (secondary):** Assessed via combination of physicians'

						scores on cycle 1 with scores on the control items in cycle 3 and normalizing scores to a percentage scale. In the per-protocol analysis, baseline CPG knowledge was significantly higher among urologists than urology residents (P < 0.001). **d. Acceptability and utilization of ISE (secondary):** Assessed via end-of-program survey. 84% of all participants requested to enroll in

						further ISE programs. Respondents reported spending a median 3 minutes (IQR: 2–5) to complete each ISE email (2 items per email). Participants reported that the optimal number of ISE emails each week would be 3 (median, IQR: 2– 4) and the optimal number of questions in each ISE email would be 2.5 (median, IQR: 2.0 – 3.0).

Abbreviations used: ASD: Aging Semantic Differential; BCC: basal cell carcinoma; CE: continuing education; CEU: continuing education unit; CI: confidence interval; CKD: chronic kidney disease; CME: continuing medical education; CPD: continuing professional development; CPG: clinical practice guideline; CT: computer-tailored; CTAS: Canadian Triage and Acuity Scale; CtC-method: Commitment-to-Change method; DCTEP: Dementia Care Training and Education Program; DKAS: Dementia Knowledge

Assessment Scale; DOS: Delirium Observation Screening; e-PBL: electronic problem-based learning; EBM: evidence-based medicine; ED: emergency department; FEP: Frail Elderly Project; GETUP: Global Educational Toxicology Uniting Project; GME: graduate medical education; GP: general practitioner; GPACS-D: General Practitioner Attitudes and Confidence Scale for Dementia; GPN: general practice nurse; ICM: I-Change Model; IMG: international medical graduate; INFORMED: Internet Curriculum for Melanoma Early Detection; IQR: interquartile range; ISE: Interactive Spaced Education; LDS: Learner Demographic Survey; LMS: Learning Management System; LSAe-L: Learner Satisfaction with Asynchronous e-Learning; MCQ: multiple-choice question; N/A: not available; NP: nurse practitioner; OLSI: Online Learner support Instrument; OP: occupational physician; OR: odds ratio; OSCE: objective structured clinical examination; PBL: problem-based learning; PC: palliative care; PCP: primary care provider; PN: practice nurse; RCT: randomized controlled trial; RN: registered nurse; RT: respiratory therapist; SCC: squamous cell carcinoma; SD: standard deviation; SHC: sexual health care; SIA: staghorn calculi, infertility, and antibiotic use; STI: sexually transmitted infection; T/F: true/false; TPB: theory of planned behavior; WeBREATHe: Web-Based Respiratory Education About Tobacco and Health.

Appendix C Mapping TDF Domains to Behaviour Change Techniques

Domain	# of BCTs	Source	BCTs
Knowledge	4	134	1. Health consequences 2. Biofeedback 3. Antecedents feedback on behaviours
	1	129	1. Information regarding behaviours outcome
Skills	5	134	1. Graded tasks 2. Behavioural rehearsal/practice (Instructions on how to perform the behaviour) 3. Habit reversal 4. Body changes 5. Habit formation
	10	129	1. Goal/target specified: behaviour or outcome 2. Monitoring 3. Self-monitoring 4. Rewards: incentives 5. Graded tasks, starting with easy tasks 6. Increasing skills: problem solving, decision making, goal setting 7. Rehearsal of relevant skills 8. Demonstration of behaviour by others/modeling 9. Homework 10. Perform behaviour in different setting
Beliefs about Capabilities	2	134	1. Verbal persuasion to boost self-efficacy 2. Focus on past success
	9	129	1. Self-monitoring 2. Graded task, starting with easy tasks 3. Increasing skills: problem solving, decision making, goal setting 4. Coping skills

			5. Rehearsal of relevant skills 6. Social process of encouragement, pressure, support 7. Feedback 8. Self-talk 9. Motivational interviewing
Beliefs about Consequences	10	134	1. Emotional consequences 2. Salience of consequences 3. Covert sensitization 4. Anticipated regret 5. Social and environmental consequences 6. Comparative imagining of future outcomes 7. Vicarious reinforcement 8. Threat 9. Pros and cons 10. Covert conditioning
	4	129	1. Self-monitoring 2. Persuasive communication 3. Information regarding behaviour, outcome 4. Feedback
Social Influences	10	134	1. Social comparison 2. Social support or encouragement (general) 3. Information about others' approval 4. Social support (emotional) 5. Social support (practical) 6. Vicarious reinforcement 7. Restructuring the social environment 8. Modelling or demonstrating the behaviour 9. Identification of self as role model 10. Social reward
	2	129	1. Social process of encouragement, pressure, support 2. Modeling/ demonstration of behaviour by others

Environmental Context and Resources	6	134	1. Restructuring the physical environment 2. Discriminative (learned) cue 3. Prompts/cues 4. Restructuring the social environment 5. Avoidance/changing 6. exposure to cues for the behaviour
	1	129	1. Environmental changes (e.g., objects to facilitate behaviour)
Behavioural Regulation	1	134	1. Self-monitoring of behaviours
	None	129	NA
Emotion	4	134	1. Reduce negative emotions 2. Emotional consequences 3. Self-assessment of affective consequences 4. Social support (emotional)
	2	129	1. Stress management 2. Coping skills
Motivation and Goals	Goals (5) Motivation (13)	134	Goals: 1. Goal setting (outcome) 2. Goal setting (behaviour) 3. Review of outcome goal(s) 4. Review behaviour goals 5. Action planning (including implementation intentions) Motivation 1. Threat 2. Self-reward 3. Differential reinforcement 4. Incentive 5. Thinning 6. Negative reinforcement 7. Shaping 8. Counter conditioning 9. Discrimination training 10. Material reward 11. Social reward 12. Non-specific reward 13. Response cost
	9	129	1. Goal/target specified: behaviour or outcome

			2. Contact 3. Rewards: incentives 4. Graded task, starting with easy tasks 5. Increasing skills: problem solving, decision making, goal setting 6. Social process of encouragement, pressure, support 7. Persuasive communication 8. Information regarding behaviour, outcome 9. motivational interviewing
Social/Professional Role and Identity	None	134	NA
	1	129	10. Social process of encouragement, pressure, support
Memory, Attention and Decision Processes	None	134	NA
	3	129	1. Self-monitoring 2. Planning, implementation 3. Prompts, triggers, cues

129 Michie et al. 2008; 134 Cane et al.2015

Appendix D Quotations mapped to TDF domains and BCTs

Domain	BCT	Example quotes
Skills	Demonstration of the behaviour by others / "modeling"	*"What kind of training? I mean, I would say* ***when I was doing my fourth year rotations and observing my preceptor in practice, that was helpful****."* (RPh 13, AB) ***"I was able to see how pharmacists practice to the full scope in their unique practice settings. I think that was, yeah, really instructive. It provided a good model for how I go about my clinical practice."*** (RPh 13, AB)
	Behavioural rehearsal/practice	***"On the job training just literally doing it."*** (RPh 16, AB)
	Graded tasks	*"You could have all the knowledge in the world, but sometimes the way a certain case is presented, and if you can talk your way through it, have case scenarios.* ***And not the easy ones, the hard ones. Okay? The easy ones, I can do that. But it's the hard ones where there's a lot of extenuating circumstances. Those are the kinds of things that I would like to see. Especially with the population that we have that's getting older, less well, more conditions, it just complicates things.****" (RPh 8, ON)*
	Instruction on how to perform a behaviour	*"A lot of the reps have come through and they will take the time to sit there and go through the machines with us.* ***When the Freestyle Libre came out, our rep came in and was there for a couple hours and she took groups of four or five each and she went through the machine with us and stuff like that.*** *So I have to say for at least the glucose monitors and stuff, we've had our reps come in and show us things and keep us up to date on stuff, which has been really great."* (Ph.Tech 19, ON)
	Increasing skills: problem solving, decision making, goal setting	*"I think you need dual. I'm all for online webinars, they're great. I do a lot of online stuff and that too as well.* ***But sometimes when you're looking at patient examples where there could be more than one decision****, say about disease or something, then I think* ***that group sessions or focus sessions or we have a lot of CMEs in our areas, the pharmacist and that too as well. So I think enabling pharmacists to get together and show how up and up a possible scenario is and how to do that is also a good idea too as well.*** (RPh 15, ON)

		*"I still find that as pharmacists, there is a percentage of pharmacists that **are not comfortable making decisions. So they don't make recommendations***." (RPh 15, ON)
Beliefs about capability	Behavioural rehearsal/practice	*"In the beginning when I'm just like, I don't know how long, but even injections like over a decade ago, like when it first started the confidence is not there, **but as one does it more, you get to be confident**. So basically practice helped you build confidence? Yes. Increase it. Yes."* (RPh 14, AB)
	Credible source	*"**What really got me going was when the inspector came by** one day and I was chatting with her and she said, 'You know, you could change anything except the drug. And just, you know, you have to just document it.' And, you know, just that **little booster of confidence from the inspector made all the difference to me. I went from being hesitant to, you know, doing what needs to be done, basically**…Because like I said earlier, I didn't really feel comfortable until the inspector gave me the go ahead and a heads up, you know? The clear explanation of what I can and cannot do."* (RPh 18, ON)
Memory, attention and decision processes	Prompts and cues	***"The format of [prescription tracking services] helps to remind me of what I need to ask or be aware of when I'm doing a prescription."*** (RPh 16, AB) *"[algorithms]are helpful in two different ways. Helpful in that sometimes they [algorithms] can help decrease the amount of paperwork I have to do. **Helpful in that they [algorithms] can remind me of what needs to be done in terms of this specific process. And that one would be specifically for the clot when we're teaching or prescribing the heparin for cancer related clots.**"* (RPh 16, AB)
	Self-monitoring of behaviour	*"It's not something that I would reference all the time, but as I sort of checkpoint every now and then, **it's good to kind of sit in, check in on those guidelines and see if we're doing what's expected of us or underachieving or maybe overstepping, that kind of thing, just to kind of rebalance yourself, probably that tool.**"* (RPh 13, AB)

Social influence	Identification of self as role model	*Speaker 1:* *"So, do you think that when you practised your full scope that will influence other technicians? To start practicing?"* *Speaker 2:* *"I hope it would.* ***I hope it would give them the courage to say, 'You know what? Yeah, I can do that too.'*** *I hope it's not like a dog eat dog world out there, where we can't use each other for support."* (Ph.Tech 23, ON)
	Social comparison	*"Honestly,* ***I would like to hear more from other practitioners who have been doing it. Okay? Who have been practicing full scope, and in [which] other provinces they have [been practicing]?*** *And it's like, what have they heard? What have they encountered? You know what I mean? It opens your mind up to kind of more possibilities, right?"* (RPh 8, ON)
	Information about others' approval	*"If I probably have more information or presentation put on by specialists saying,* ***'Okay, this is a red flag, you don't touch it if they do this.'*** *Versus what I'm reading, versus what's written out in journals, how to treat things. So if I actually saw a specialist let's say, who has specialized in breast cancer. And they do a big conference talk and said,* ***'Okay, I know you're getting my patients and I know they're asking for stuff like this. These are the no-nos, don't touch this. This is when you refer to me'.*** *And then they can also say, 'Okay, you can do anything to this patient with breast cancer because I know that it won't affect anything that I'm doing.'"* (RPh 11, AB)
	BCT- Social reward	*Speaker 1:* *"So, how does practicing full scope activities make you feel?"* *Speaker 2:* ***"It's rewarding."*** (RPh 9, AB)
	BCT- Social support or encouragement	*"So I guess because I'm a more experienced pharmacist, I often get calls from other people on staff, and from new grads when they're coming through, and we run through cases together and we learn that way.* ***So yes, having a physical person to run a case by and ask a question****, 'Have you seen this before, and what would you suggest?' And being able to talk through the case, because sometimes you have to piece out a little bit more information than what they're giving*

		you. Yes, so I would say yes I have influenced a fair amount of students." (RPh 22, ON)
Beliefs about consequences	Salience of consequences = Information regarding behaviour, outcome	*"**Certainly helps patients feel like [patients] are getting their care faster** rather than us saying, 'Oh, well. I'll have to leave a note from the doctor or call the doctor,' or whatever and delay something by like a day or more. If it's something that we can do for them right away, it certainly helps them feel like things are moving faster. [Patients] are cared for more efficiently."* (RPh 13, AB)
	Information about social and environmental consequences	*"I think that operating full scope actually gives you a **better relationship with the patient because they trust you already. But then as soon as you start providing these other services, it just feels like the respect that they have for you goes up.** I think it's great."* (RPh 6, ON)
	Comparative imagining of future outcomes	*"So I suppose **if somebody told me tomorrow that all of my ability to prescribe—whether it was to initiate, refill, adapt, whatever—was taken away, I would probably be pretty disappointed and frankly speed up my retirement process**. And feel sorry for those that are coming behind me."* (RPh 16, AB)
	Vicarious consequences	*"Like with everything, there will be pharmacists, I believe, that will not want to do the extended scope. **Just like when we first finally got doing flu shots, there were pharmacists that I know that said, 'I don't want to do that.' Okay, they lost their jobs**, but they lost their job because they said, 'I don't want to be giving injections to people.'"* (RPh 1, ON)
Environmental context and resources	Restructuring the physical environment	*"I would like to see a little more, **let's say, patient privacy or patient counseling rooms**. You know, most pharmacies only have one. Sometimes I think it would be beneficial to have more than one because there are things that I could be doing with a patient and the pharmacist could be doing [things] with another patient simultaneously."* (Ph.Tech 7, ON)
	Restructuring the social environment	*"And **the other thing is the scheduling appointments**—and I know many pharmacies try to do that—but it hasn't worked out, well, in our community anyway. **So, I think that would help to allow you to be full scope.**"* (RPh 12, NS)

Alberta AB; British Columbia BC; Nova Scotia NS; Ontario ON

Appendix E Content Validity Index of the Knowledge Test Items (33 Items)

	Evaluator								
Question	*Exp1*	*Exp2*	*Exp3*	*Exp4*	*Exp5*	*Exp6*	*Exp7*	**Total # of experts voting 3 or 4**	**I-CVI score**
1	4	2	4	4	1	4	3	5	71.42857143
2	3	4	4	4	2	4	4	6	85.71428571
3	3	4	3	3	1	4	3	6	85.71428571
4	4	4	3	1	4	3	4	6	85.71428571
5	4	4	3	4	4	3	4	7	100
6	3	3	3	3	2	3	4	6	85.71428571
7	4	4	3	3	4	3	4	7	100
8	3	2	2	3	3	3	4	5	71.42857143
9	3	4	3	4	4	4	4	7	100
10	4	3	4	4	1	4	4	6	85.71428571
11	2	3	2	3	4	3	4	5	71.42857143
12a	3	2	3	4	4	3	4	6	85.71428571
12b	3	2	3	4	4	3	4	6	85.71428571
12c	3	3	3	4	2	2	4	5	71.42857143
12d	4	3	4	4	2	4	4	6	85.71428571
13a	3	4	4	4	2	3	4	6	85.71428571
13b	4	4	3	4	4	3	4	7	100
13c	4	4	4	4	3	3	4	7	100
14a	4	4	3	4	2	3	4	6	85.71428571
14b	3	4	4	3	4	3	4	7	100

14c	3	4	4	3	2	3	4	6	85.71428571
14d	4	4	4	4	1	2	4	5	71.42857143
14e	4	4	4	4	1	4	4	6	85.71428571
14f	3	4	4	3	1	3	3	6	85.71428571
15a	4	4	3	4	4	3	4	7	100
15b	3	4	4	4	2	3	4	6	85.71428571
15c	4	4	4	4	4	3	4	7	100
16a	4	4	4	4	4	3	4	7	100
16b	4	4	4	4	1	3	4	6	85.71428571
16c	3	4	3	4	1	3	4	6	85.71428571
16d	4	4	4	4	3	4	4	7	100
17 Rx1	4	4	4	2	3	3	4	6	85.71428571
17 Rx2	4	4	4	2	3	2	4	5	71.42857143

means number

Appendix F The Final Version of the Knowledge Test (22 Items)

Q1) Which of the following factors/situations can worsen or intensify anticholinergic side effects?

a) Increasing the daily dose of quetiapine from 100 mg to 200 mg
b) Adding olanzapine to concurrent pseudoephedrine therapy
c) Patient is an older adult
d) All of the above
e) (a) and (b) only

Q2) Which of the following antidepressant drugs has less anticholinergic activity than paroxetine, which is highly anticholinergic?

a) Citalopram
b) Sertraline
c) Desipramine
d) All of the above
e) (a) and (b) only

Q3) A patient has been taking baclofen for many years, and is complaining of dry mouth, dry skin and difficulty urinating. Recently tramadol was added to their therapy. Which of the following would you expect to happen?

a) A worsening of dry mouth
b) A worsening of dry skin
c) More difficulty urinating
d) All of the above
e) (a) and (b) only

Q4) Symptoms of mild anticholinergic toxicity include:

a) Dilated pupils
b) Dry mouth
c) Seizures
d) All of the above
e) (a) and (b) only

Q5) A patient has taken paroxetine for many years with no reported anticholinergic effects. After 10 years, at the age of 72, the patient starts to notice some dry mouth. Could paroxetine be causing these symptoms now, even though it was not in the past?

a) Yes

b) No

Q6) Symptoms of anticholinergic effects can occur within:

a) 1 -2 hours of taking anticholinergic drugs
b) 12-24 hours of taking anticholinergic drugs
c) 2-4 days of taking anticholinergic drugs
d) 1-2 weeks of taking anticholinergic drugs

Q7) A patient taking oxcarbazepine who complains of urinary retention and dry skin is switched to lamotrigine. How would you expect their complaints to be affected by the drug change?

a) Less urinary retention and less dry skin
b) More urinary retention and more dry skin
c) Less urinary retention and more dry skin
d) More urinary retention and less dry skin

Q8) P.J. is a frail 81-year-old male patient with hypertension and insomnia. His current medication list includes: doxepin 3 mg once daily at bedtime and lisinopril 10 mg once daily.

Q8.a) Which of the following factors put P.J. at higher risk for serious anticholinergic side effects?

a) Age
b) Use of doxepin
c) Hypertension
d) All of the above
e) (a) and (b) only

Today P.J. comes to your pharmacy complaining of dry mouth and urinary retention for the past 3 days. Last week, P.J.'s doctor increased the doxepin dose to 6 mg once daily at bedtime to help address his symptoms of insomnia. P.J. tells you that he has been taking 2 tablets of doxepin 6 mg at bedtime since he could not sleep.

Q8. b) What could you do to help P.J.?

a) Call or fax the prescriber to request a new prescription for a dose reduction of the doxepin dose down to 3 mg once at bedtime.
b) Call or fax the prescriber to recommend stopping the doxepin and switching to trazodone.
c) Refer P.J to his primary care provider to get a medication to treat urinary retention.

Q9) M.K., a 52-year-old female patient, comes to the pharmacy to ask for your recommendation for the appropriate dose for loperamide. She has been experiencing mild

diarrhea for the past two days. She is not taking any chronic medications or OTC drugs other than acetaminophen for an occasional headache.

Q9.a) Loperamide is classified as a drug with what level of anticholinergic activity?

a) Low anticholinergic activity
b) Moderate/high anticholinergic activity

Q9.b) M.K has one or more attributes that put her at risk for serious anticholinergic side effects.

a) True
b) False

Q9.c) Which measure(s) should you take/recommend to help prevent anticholinergic toxicity with her use of loperamide?

a) Advise M.K. to use the lowest effective dose; not to exceed 16 mg/day
b) Teach MK to recognize the signs of anticholinergic side effects and toxicity
c) Follow up with M.K. 1-2 days after starting loperamide to ensure the maximum dose hasn't been exceeded
d) All of the above
e) (a) and (b) only

Q10) H.A. a 71-year-old man, comes to your pharmacy complaining of back pain for the past 2 days after lifting a heavy bag. He asks for your advice on taking an OTC muscle relaxant with methocarbamol. After a thorough assessment, you determine that H.A. is not taking any prescribed medications. He only takes diphenhydramine every other night to help him sleep.

Q10.a) Methocarbamol is classified as a drug with what level of anticholinergic activity?

a) Low anticholinergic activity
b) Moderate/high anticholinergic activity

Q10.b) What would you recommend to help H.A. manage his back pain and minimize the chance of any adverse effects from the medication?

a) Advise H.A. to use a methocarbamol product two tablets every 6 hours
b) Advise H.A. to use acetaminophen 500 mg 1 to 2 tablets every 4 to 6 hours as needed
c) Advise H.A. to use orphenadrine 100 mg twice daily

Q11) S.S. a 67-year-old female patient with type 2 diabetes, hypertension and dyslipidemia, comes to the pharmacy for a medication review. Her current medication list includes metformin, lisinopril, atorvastatin, ranitidine, ipratropium and oxybutynin.

Current blood pressure 126/73, heart rate 90, HbA1C% 6.7, lipid profile within normal range

Drug	Indication	Duration
Metformin 500 mg twice daily	for type 2 diabetes	For 3 years
Lisinopril 10 mg daily	for hypertension	For 5 years
Atorvastatin 20 MG daily	for dyslipidemia	For 5 years
Oxybutynin XL 10 mg daily	for urinary incontinence	For 30 days
Ranitidine150 mg daily	SS is not sure why she is taking it	For 3 years
Ipratropium 2 INH three to four times daily when needed	Had an episode of shortness of breath 2 years ago but still on it	For 2 years

Q11.a) Which of the following drugs is classified as having moderate/high anticholinergic activity?

a) Oxybutynin
b) Metformin
c) Ranitidine
d) Ipratropium

Q11.b) What other information do you need to collect to better assess for the risk of anticholinergic toxicity?

a) Any over the counter (OTC) drug use
b) Patient's awareness of the signs of anticholinergic side effects and toxicity
c) How often her conditions are being reassessed by her primary care provider(s)
d) All of the above
e) Only (a) and (b)

Q11.c) After completing the medication review and assessment of all S.S's medications, using the resources provided, please write your recommendation/(s) to S.S.'s family doctor, as you would in your practice site.

……
……
……

Q12) K.L., a 72-year-old male patient, comes to the pharmacy to pick up his prescription for citalopram. His current medication list includes captopril 12.5 three times daily, risperidone 4 mg daily, ranitidine 150 mg once daily, carbidopa/levodopa 100/25 three times a day, and trazodone 50 mg at bedtime. All his medical conditions are currently stable and he is not complaining of any side effects. He denies taking any over the counter (OTC) medications.

Q12.a) Which of the following factors put K.L. at an increased risk for serious anticholinergic side effects?

a) Age
b) Taking multiple medications
c) History of Parkinson's disease
d) All of the above
e) (a) and (b) only

Three weeks later, K.L. comes back to the pharmacy with a new prescription, increasing the dose for ranitidine 150 mg to twice daily for his ongoing heartburn.

Q12.b) Could this change in K.L.'s drug regimen increase his risk for anticholinergic side effects?

a) Yes
b) No

Q12.c) What might you do to help lessen K.L.'s risk for possible anticholinergic side effects?

a) Follow up K.L 1-2 days after any dose increase in a medication with anticholinergic activity 1 to assess for new side effects
b) Reassess the need for anticholinergic drugs annually
c) Teach K.L to recognize the signs of anticholinergic side effects and toxicity
d) All of the above
e) (a) and (b) only

13. Based on your clinical judgement, would you fill the following prescriptions?

Please select the best answer from the choices provided, then provide a recommendation according to your choice.

Rx 1

Dr. N. Price-Munn
124 Victoria St. N.
Kitchener, Ont.
519-885-7676
CPSO# 12657

Ochu Owayo
10 Heinz Ave
Kitchener, ON
519-885-7867
May 12, 1944
HC# 123 543 901

Hydroxyzine 25 mg three times daily when needed for allergic pruritus

M: 60 capsules
R: 0

Dr. C. Price-Nunn

Ochu Owayo	**Allergies:** Peanuts			
DOB May 12, 1944	**Medical Conditions:** Depression, hypertension			
Last Fill	Drug	Quantitiy Filled	Quantity Remaining	Prescriber
3 months ago	Paroxetine 30 mg daily	100	0	Price-Munn, N
3 months ago	Ramipril 5mg daily	100	0	Price-Munn, N
6 months ago	Paroxetine 30 mg daily	100	100	Price-Munn, N
6 months ago	Ramipril 5mg daily	100	100	Price-Munn, N
9 months ago	Paroxetine 30 mg daily	100	200	Price-Munn, N
9 months ago	Ramipril 5mg daily	100	200	Price-Munn, N

a. Fill the prescription as is
b. Fill the prescription with patient education
    - if (b) chosen: Please write what would you say to educate the patient
c. Contact the prescriber to offer an alternative
    - if (c) chosen: please write your recommendation to the prescriber as you would in your practice site.

Rx 2

Dr. C. Min
124 Victoria St. N.
Kitchener, Ont.
519-885-7676
CPSO# 12657

Shah Brar
15 Rosamund Ave
Waterloo, ON
519-885-7867
March 15, 1950
HC# 123 543 901

Amitriptyline 25 mg QHS
for neuropathic pain
M: 30 days
R: 0

Dr. C. Min

Shah Brar **Allergies:** NKDA
DOB March 15, 1950 **Medical Conditions:** Dyslipidemia, Dementia

Last Fill	Drug	Quantitiy Filled	Quantity Remaining	Prescriber
3 months ago	Donepezil 10 mg daily	100	0	Dr. C. Min
3 months ago	Atorvastatin 10 mg daily	100	0	Dr. C. Min
6 months ago	Donepezil 10 mg daily	100	100	Dr. C. Min
6 months ago	Atorvastatin 10 mg daily	100	100	Dr. C. Min
9 months ago	Donepezil 10 mg daily	100	200	Dr. C. Min
9 months ago	Atorvastatin 10 mg daily	100	200	Dr. C. Min

a. Fill the prescription as is
b. Fill the prescription with patient education
    - if (b) chosen: Please write what would you say to educate the patient
c. Contact the prescriber to offer an alternative
    - if (c) chosen: please write your recommendation to the prescriber as you would in your practice site.

Appendix G Subgroup Analysis of Post-Test Knowledge Multiple Choice Questions

Questions	Study group			
	Intervention group n = 50		Control group n = 51	
	Correct	Incorrect	Correct	Incorrect
Q1	47	3	45	6
Q2	36	14	48	3
Q3	49	1	40	11
Q4	37	13	39	12
Q5	43	7	47	4
Q6	45	5	44	7
Q7	46	4	47	4
Q8.a	5	45	12	39
Q8.b	44	6	45	6
Q9.a	41	9	39	12
Q9.b	39	11	41	10
Q9.c	48	2	45	6
Q10.a	42	8	46	5
Q10.b	48	2	48	3
Q11.a	48	2	49	2
Q11.b	41	9	44	7
Q12.a	4	46	13	38
Q12.b	44	6	49	2
Q12.c	48	2	50	1

Appendix H Subgroup Analysis of Post-Test Knowledge Open-Ended Questions

Rx	Study group					
	Intervention group n = 50			Control group n = 51		
	Fill as is	Fill the prescription with education	Contact prescriber to offer an alternative	Fill as is	Fill the prescription with education	Contact prescriber to offer an alternative
Rx 1	2	11	37	1	18	32
Rx 2	2	10	38	1	4	46