Informing the Development of a Chatbot for Pharmacist Needs in HIV Care

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ABSTRACT

Background: Chatbots – "conversational agents" – are computer programs designed to mimic conversations with human users. Recent advances in artificial intelligence (AI) algorithms and their application in digital healthcare have made AI-based chatbots increasingly valuable. Chatbots have become progressively more popular in various industries, including healthcare, as they offer numerous benefits to patients and healthcare providers alike. Chatbots can help healthcare providers with tasks such as retrieving health- and medication-related information, keeping medical records, scheduling appointments, and triaging patient concerns. For instance, pharmacists need up-to-date HIV- and antiretroviral therapy (ART)-related information when counseling people with HIV (PWH). However, with thousands of academic articles on prescription and non-prescription medications published each year, they find it challenging to stay current on every aspect of HIV care. MARVIN, an artificial intelligence-based chatbot developed to assist PWH in taking ART, initially developed in 2020, could be adapted to respond to this need.

Aim: The aim of this thesis was to generate evidence on the needs of pharmacists to inform the adaptation of the MARVIN chatbot for improving services provided to PWH in Québec, Canada.

Methods: This thesis consists of two manuscripts. The first manuscript provides a comprehensive review of the roles and benefits chatbots offer in healthcare and the populations they serve. The second manuscript entails a preliminary report that summarizes the design, conduct and results of an online survey to assess the HIV care needs of pharmacists in Québec, Canada, deployed between December 2022 and May 2023. For the first manuscript, a rapid review was performed, and data extracted on chatbot roles, users, and benefits were synthesized using content analysis. For the second manuscript (preliminary report), an online needs assessment questionnaire based on the Knowledge, Attitudes and Practices (KAP) model was administered to pharmacists, and response distributions descriptively analyzed to elicit central tendencies and variations with regard to knowledge, attitudes and practices.

Results: The findings from the rapid review and the needs assessment questionnaire provide valuable insights that inform the recommendations and implications for the adaptation and development of MARVIN-Pharma in HIV care.

Key conclusions based on the rapid review suggest that adapting an AI chatbot to meet the specific needs of pharmacists in HIV care can significantly enhance support for PWH. By providing remote consultation and treatment advice, facilitating medication management, offering educational

resources, and streamlining administrative tasks, the chatbot can empower pharmacists to deliver more effective and personalized care, ultimately improving health outcomes for PWH.

Key conclusions based on the pharmacist needs assessment questionnaire for MARVIN-Pharma include the necessity for MARVIN-Pharma to address pharmacists' knowledge gaps in HIV treatment; provide targeted educational and training materials; integrate patient information needs; support various HIV care services; and address barriers facing pharmacists in HIV care. User-friendly design, continuous support, and gathering user feedback are essential for enhancing the usability and effectiveness of MARVIN-Pharma, as well as connecting it with a constantly updated, reliable HIV information resource.

Conclusion: These findings and recommendations provide insights for the content configuration and development of MARVIN-Pharma, guiding its design and development to meet the needs of pharmacists in HIV care as an innovative, practical tool.

RÉSUMÉ

Contexte : Les chatbots, appelés "agents conversationnels intelligents", sont des programmes imitant les dialogues humains. L'essor de l'intelligence artificielle (IA) dans les soins numériques a renforcé les chatbots IA, notamment en santé. Ils sont prisés dans divers secteurs, y compris la santé, car ils bénéficient autant aux patients qu'aux soignants. Ils aident à rechercher des informations médicales, gérer des dossiers, fixer des rendez-vous et trier les préoccupations des patients. De plus, les pharmaciens ont du mal à suivre les innombrables articles médicaux publiés annuellement sur le VIH et ses traitements. Le chatbot MARVIN, conçu en 2020 pour aider les personnes avec le VIH à mieux suivre leurs traitements, pourrait aider à cette tâche.

Objectif : La thèse cherche à évaluer les besoins des pharmaciens québécois pour mieux informer leurs patients avec le VIH afin que le chatbot MARVIN les assiste au mieux dans cette tâche.

Méthodes : La thèse se présente en deux parties. D'abord, elle passe en revue les rôles et bénéfices des chatbots en santé et pour les populations cibles. Ensuite, elle résume la conception, la mise en place et les résultats d'une enquête en ligne menée de décembre 2022 à mai 2023 évaluant les besoins des pharmaciens québécois en matière de soins VIH. Une analyse rapide des données extraites éclaire les rôles, utilisateurs et avantages des chatbots. Les réponses au questionnaire basé sur le modèle Connaissances, Attitudes et Pratiques (CAP) sont ensuite analysées pour identifier tendances et variations concernant connaissances, attitudes et pratiques.

Résultats : Les résultats de l'analyse rapide et du questionnaire offrent des informations essentielles orientant l'adaptation et le développement de MARVIN-Pharma dans les soins VIH. L'analyse rapide suggère qu'ajuster un chatbot IA aux besoins des pharmaciens peut considérablement améliorer leur soutien aux personnes avec le VIH. En proposant conseils à distance, simplifiant la gestion médicamenteuse, en fournissant les ressources éducatives et en allégeant les tâches administratives, le chatbot facilite l'offre de soins personnalisés et efficaces, améliorant la santé des personnes avec le VIH. Le questionnaire révèle que MARVIN-Pharma peut combler les lacunes des pharmaciens en connaissances du VIH, proposer une éducation ciblée, intégrer les besoins d'informations des patients, soutenir divers services liés au VIH et lever obstacles dans les soins VIH. Une conception intuitive, un soutien continu et une rétroaction des utilisateurs sont clés pour améliorer la convivialité et l'efficacité de MARVIN-Pharma, en le reliant à une source d'informations VIH fiable et à jour.

Conclusion : Ces résultats et recommandations guident le contenu et le développement de MARVIN-Pharma, le modelant en outil novateur et pratique répondant aux besoins des pharmaciens dans les soins VIH.

List of Abbreviations

AI	Artificial Intelligence
AIDS	Acquired Immune Deficiency Syndrome
App(s)	Application(s)
ART	Antiretroviral therapy (Antiretroviral treatment)
CHUM	Centre hospitalier de l'Université de Montréal
CIHR	Canadian Institutes of Health Research
CVIS	Chronic Viral Illness Service
E-Health	Electronic health
ECA	Embodied Conversational Agent
HCPs	Healthcare providers/ Healthcare professionals
HIV	Human Immunodeficiency Virus
ICA	Independent Component Analysis
ISO	International Organization for Standardization
IT	Information Technology
KABP	Knowledge, Attitude, Behavior, and Practice
KAP	Knowledge, Attitudes, and Practices / Knowledge-Attitudes-Practices
M-health	Mobile Health
MARVIN	Minimal AntiretRoViral INterference
MARVIN-Pharma	Minimal AntiretRoViral INterference for Pharmacists
MSM	Men who have sex with men
MTM	Medication Therapy Management
MUHC	McGill University Health Centre
NLP	Natural Language Processing
PHAC	Public Health Agency of Canada
PIHVOT	Partnerships to Improve HIV Outcomes and Treatments
PNMVH	Programme National de Mentorat sur le VIH et les Hépatites
PrEP	Pre-Exposure Prophylaxis
PWH	People with HIV
REB	Research Ethics Board
SPOR	Strategy for Patient-Oriented Research

TAM	Technology Acceptance Model
TCPS	Tri-Council Policy Statement
Q	Question
QUAN	Quantitative
QUAL	Qualitative

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I express my gratitude to Eng. Yuanchao Ma, Dr. David Lessard, and Dr. Kim Engler for their invaluable support throughout the entire process of completing this thesis. Furthermore, I extend my appreciation to Dr. Serge Vicente for his guidance in finalizing the statistical analysis presented in Chapter 3.

To my beloved parents, whose unwavering support and endless love have been the guiding lights on my academic journey, I extend my deepest gratitude and love.

PREFACE

Contribution of Authors

I, Moustafa Laymouna, have performed the majority of work for Manuscript 1, "Rapid Review of Roles, Users, and Benefits of Chatbots in Healthcare", generating the protocol, designing the search strategy with the librarian, screening the search results, extracting the relevant data from the included studies, conducting the data analysis and writing the manuscript in Chapter 2.

For Manuscript 2, the preliminary report, "Informing the Development of a Chatbot to Pharmacist Needs in HIV Care: Preliminary Results from a Knowledge-Attitudes-Practices Questionnaire", I contributed to the administration process to obtain study REB exemption, the recruitment of pharmacists, collection and analysis of the preliminary results, and to writing the report. I was also responsible for writing the other chapters of this thesis. This project is part of a wider project aiming to inform the adaptation of the MARVIN chatbot to pharmacists, led by Dr. Lebouché and Rachel Terrien (pharmacist) and funded by Partnerships to Improve HIV Outcomes and Treatments (PIHVOT) from ViiV Healthcare.

However, both manuscripts were only made possible as a result of the contributions of

several co-authors. Both manuscripts and chapters included in this thesis are the work of the master's candidate, Moustafa Laymouna, with editing and feedback from Drs. Lebouché and Schuster, and support from all members of the thesis supervisory committee. As supervisors, Drs. Lebouché and Schuster oversaw all aspects of the thesis and provided expertise regarding research methodology and statistical analyses. Drs. Engler and Lessard, research associates with Dr. Lebouché, provided professional feedback for both manuscripts. Eng. Yuanchao Ma, a doctoral candidate at Polytechnique Montreal, associated with and co-supervised by Dr. Lebouché, also helped with both manuscripts. The rapid review has already been submitted for publication, while the preliminary report will undergo a cycle of reviews by the co-authors to be submitted for publication after the submission and acceptance of this thesis.

Thesis Organization and Overview

Related manuscripts and presentations

This thesis consists of two manuscripts: The first manuscript: "Rapid Review of Roles, Users, and Benefits of Chatbots in Healthcare" is expected to be submitted to the Journal of Medical Internet Research and abstracts related to this work were presented at two conferences. One titled "Uses and Impacts of Chatbots in Healthcare" was recently published and presented as an oral presentation at the 7th Annual McGill Family Medicine Research Symposium, held on May 12-13, 2022. In addition, an abstract titled "Artificial Intelligence-Based Chatbots in Healthcare: Uses and impacts" was published and presented as a poster at the Family Medicine Forum (FMF) 2022, held on November 16-19, 2022.

The second manuscript: "Informing the Development of a Chatbot to Pharmacist Needs in HIV Care: Preliminary Results from a Knowledge-Attitudes-Practices Questionnaire", will be submitted for publication after the submission of this thesis. Abstracts based on this work were submitted to three conferences. One titled, "Adaptation of the MARVIN Chatbot to Pharmacist Needs for HIV Care: Report of Preliminary Results from an Online Survey" was presented as a poster at the 7th Annual Infectious Diseases and Immunity in Global Health (IDIGH) Research Day on May 5th, 2023. The second abstract was presented as an oral presentation at the McGill Department of Family Medicine Annual Retreat in October 2023. The third abstract has been submitted for a poster presentation at e-Health 2024, which is

scheduled for May 2024 in Vancouver, Canada.

To comply with the requirements of the Graduate and Postdoctoral Studies (GPS), additional chapters and sections (background, comprehensive literature review and overall conclusion) were included in this thesis. These demonstrate the natural progression and initial research work required to prepare both manuscripts. As required by the GPS, introductory and concluding sections, independent of the manuscripts, were incorporated into the thesis. McGill University guidelines for a manuscript-based thesis were followed, which recognize each manuscript as a concise document.

This thesis responds to two objectives presented in sequence within the chapters and the associated manuscript. The first objective (Manuscript 1) is to provide an overview of the existing chatbots used in healthcare concerning their roles, users, and benefits. The second objective (Manuscript 2) is to provide information that will help adapt the MARVIN chatbot to pharmacist needs for HIV care.

This thesis is structured as follows:

Chapter 1: Introduction (includes both background and a comprehensive literature review).

Chapter 2: Manuscript 1 provides a comprehensive review of the roles and benefits chatbots offer in healthcare and the populations they serve.

Chapter 3: Manuscript 2 provides the design and preliminary results of an online knowledge-attitudes-practices questionnaire for informing the adaptation of MARVIN to pharmacists' needs for HIV care.

Chapter 4: Overall Conclusion.

Tables and figures are presented in both manuscripts. The appendices include information that was important to include in the thesis but not necessarily presented in the rapid review or the preliminary report.

In addition, references for all sections of the thesis, except Manuscript 1, are included at the end of the last chapter.

Chapter 1: Introduction

Background

The human immunodeficiency virus (HIV) has been a persistent public health challenge since its first recognition in the 1980s [1,2]. Despite significant advancements in prevention and treatment strategies, HIV remains a major public health problem globally. The development of combination antiretroviral therapy (ART) has reduced both HIV transmission events and AIDS-related deaths [3]. ART has been successful in suppressing HIV replication and restoring immune function, enabling HIV-positive individuals to manage the disease as a chronic illness and live a near-normal lifespan [4-6]. Nevertheless, according to recent data from the Public Health Agency of Canada (PHAC), in 2021, there were 1,472 new HIV diagnoses and an estimated 62,790 people with HIV (PWH) in Canada [7-10]. These statistics underscore the ongoing need for continued efforts to address the challenges posed by the HIV epidemic.

Adherence to ART is crucial in managing HIV, as it is associated with reduced morbidity and mortality among PWH [11]. However, poor adherence can lead to severe consequences, including viral rebound and transmission of drug-resistant strains of HIV [12]. Achieving an undetectable viral load is important for disease progression, transmission risk reduction, and long-term viral suppression. By attaining this state, PWH can reduce their frequency of physician consultations as the condition transitions to a chronic phase, while continuing regular visits to pharmacists for the necessary ART refills. Adherence to ART remains a challenge for many patients [13,14] and is influenced by various factors such as psychosocial issues (e.g., substance abuse, lack of social support) as well as treatment barriers and side effects [15-22]. Conversely, positive correlations with adherence include weight gain, improved health, increased knowledge, and longer intervals between HIV diagnosis and initiation of ART [11,23-26].

Considering that HIV is a persistent but controllable health condition, continual support is crucial to ensure long-term adherence. Patients require comprehensive information regarding potential interactions between their ART and other medications they may be taking, as well as detailed knowledge about potential side effects. Effective education and counseling play a pivotal role in promoting adherence to ART and achieving desired virologic outcome. Pharmacists are well-positioned to assist patients in this regard.

In today's healthcare system, managing HIV requires interprofessional efforts, and pharmacists play a significant role in the care of PWH [27-29]. As the healthcare professionals most accessible

to the public, pharmacists often serve as the first and most regular point of contact for patients seeking medical treatment and advice [30-33], especially in community pharmacies, which offer access to medications and health-related advice [34]. Studies have shown that customers trust HIV screening and monitoring services in community pharmacies and are comfortable with pharmacists providing these services [35]. In addition, pharmacists are well-equipped to help meet the challenges of HIV care, including providing comprehensive primary care to PWH and identifying long-term complications associated with HIV infection and ART [36].

Indeed, pharmacists have taken on extensive responsibilities in HIV care which encompass patient education and medication counseling, as well as compounding, checking, and dispensing prescription drugs [36]. By engaging in these critical activities, pharmacists directly contribute to promoting adherence to ART among PWH. Their expertise in educating patients about medication regimens, addressing concerns related to drug interactions, and providing comprehensive counseling significantly enhances patients' understanding and adherence to prescribed treatment plans. Through their efforts, pharmacists play a crucial role in supporting PWH in maintaining optimal adherence to ART, leading to improved health outcomes and enhanced virologic control.

In the interprofessional healthcare environment, pharmacists are involved in providing education to patients about medication-related care, assessing patients' willingness and ability to adhere to ART regimens, providing initial or follow-up counseling on HIV-related disease and ART medications, and evaluating adherence to therapeutic regimens and drug-drug interactions [36,37]. However, the rapid pace of advancements in HIV care means that pharmacists must continuously seek current information to provide optimal patient care [38]. Pharmacists are often valuable sources of drug information for patients and other healthcare providers. However, they need access to reliable sources of current, accurate, and relevant information in order to remain knowledgeable about the vast number of prescription and non-prescription medications available on the market [38]. Access to quality research resources on medications and the ability to use them effectively is critical for pharmacists to provide accurate information to patients and other healthcare providers [38].

Problem Statement: With a wide range of prescription and non-prescription drugs available in Canada for HIV and the large number of biomedical journal articles published each year, pharmacists experience tremendous difficulty staying abreast of recent advances, especially with their limited time and recent increases in workload as a result of their expanded patient care roles

[39]. In addition to the aforementioned challenges, it is important to acknowledge that many pharmacists have limited exposure to HIV counseling due to the relatively low number of PWH they encounter in their practice. Consequently, this lack of regular interaction with PWH can result in a deficiency of specialized knowledge and expertise in HIV-related treatments. Given the expanding patient care responsibilities shouldered by pharmacists, it has become increasingly crucial for them to have access to readily available and reliable information regarding HIV drugs and overall health. With this, pharmacists can efficiently navigate the vast array of treatment options specific to HIV and effectively address the inquiries and concerns of PWH in a manner that is comprehensible and tailored to their needs.

Proposed Solution: Known also as "conversational agents," chatbots are computer programs designed to mimic human conversation through various platforms, including websites, texting apps, and computer software [42-53]. Chatbots have been widely applied in various industries [55,57], including education, e-commerce, finance, news, healthcare, and entertainment. The healthcare industry has seen a rapid transformation with the advent of digital technologies. The integration of chatbots in healthcare is among the most significant of these advancements. The use of artificial intelligence (AI) in healthcare has led to the creation of chatbots that can instantly answer users' questions in a user-friendly and easily accessible manner, regardless of age or literacy level. Chatbots have emerged as a promising solution for facilitating the retrieval of medical information, including in the context of HIV and ART [40,41]. Chatbots act as virtual assistants that can effectively and efficiently understand and answer questions [55,56].

The provision of validated HIV information to pharmacists could be significantly facilitated through the utilization of chatbots [54]. For example, Amazon's Alexa and eBay's ShopBot are well-known AI chatbots in the e-commerce industry [58]. In the context of healthcare, chatbot use has been met with a positive response from various patient populations and is associated with evidence-based health improvements [59-62].

Research with healthcare providers indicates that prospective chatbot users express a significant need for information regarding medications, including their interactions with other drugs and dietary supplements [54,63]. Therefore, chatbots could provide an innovative solution for pharmacists in the healthcare industry, allowing them to access essential information and counsel PWH in a cost-effective and efficient manner, ultimately leading to improved quality of care. Hence, the overarching goal is to develop a unique AI-based chatbot and connect it with a

constantly updated and verified source of information to help pharmacists serve their HIV patients. To do so, their precise needs in this regard require assessment.

Opportunity to Fill the Knowledge Gap: During the Covid-19 pandemic, a team of experts, including physicians, pharmacists, PWH, researchers, and engineers at the McGill University Health Centre guided the development of an innovative AI chatbot called Minimal AntiretRoViral Interference (MARVIN). Running on Facebook Messenger, MARVIN was created as a retrieval-based independent component analysis (ICA) trained to chat with PWH about various aspects of self-management of HIV in both English and French. As far as we know, chatbots in healthcare have yet to be based on a targeted assessment of user needs, and little guidance is available to developers to design chatbots for healthcare providers. The existing literature reveals a significant knowledge gap in the field of chatbot utilization, specifically for pharmacists involved in HIV care. Through a comprehensive review of the available literature, to the best of my knowledge, there are currently no known chatbots, based on a targeted needs assessment, developed for this purpose in any other setting. By acknowledging this gap, this study indirectly aims to address the lack of research and development of chatbot tools tailored specifically for pharmacists working in HIV care, thus contributing to the advancement of technology-driven support systems in this critical domain of healthcare. Our team will do so by configuring our existing AI-based chatbot (MARVIN) for pharmacists involved in HIV care to create MARVIN-Pharma. It will be developed and trained to converse with pharmacists and instantly answer their HIV-related questions with verified information in simple English or French, to assist them in providing fast and reliable information to PWH.

Research Aim and Objectives

Research Aim

In this thesis, I aim to provide evidence-based knowledge that will inform the subsequent adaptation, development and implementation of MARVIN-pharma tailored to the needs and preferences of Québec pharmacists involved in HIV care.

Research Objectives

- To review the literature on existing chatbots used in healthcare as to their roles, users, and benefits.
- To describe the current practice of pharmacists in HIV care in Québec, Canada, in terms of:

    - Their level of knowledge and preparedness to counsel PWH;
    - Their attitudes and comfort level towards providing HIV care;
    - Their level of involvement in HIV care; and
    - The barriers facing them in HIV care delivery.
- To describe pharmacist views about MARVIN-Pharma in terms of:
    - Its acceptability, compatibility with their work, and their perceived self-efficacy to use it; and
    - Their needs and preferences for the chatbot characteristics, functions, content, and information.

Literature Review

HIV remains a persistent public health concern in Canada, and overcoming barriers to accessing ART, along with addressing stigma and discrimination, continues to be a challenge. While ART has substantially improved health outcomes for PWH, it is essential to recognize that non-adherence and suboptimal regimens can result in significant consequences, including treatment failure, side effects, drug resistance, drug interactions, comorbidities, and susceptibility to viral coinfections and opportunistic infections. Furthermore, limited access to healthcare and social support, along with mental health and psychosocial issues, can exacerbate these challenges.

To effectively manage HIV and mitigate these complications, adherence to treatment and active involvement from healthcare providers play critical roles.

ART Adherence as Challenging and Complex

Consistent adherence to ART is essential for achieving and maintaining viral suppression in PWH [64-77]. However, ensuring regular adherence poses an ongoing and complex challenge in their care [78,79].

ART regimens for PWH typically require lifelong adherence to maintain an undetectable viral load [80-82]. This sustained adherence is crucial for positive health outcomes associated with ART [80-85], including suppressing viral replication, slowing disease progression, reducing mortality rates, preventing viral resistance, and promoting immune regeneration [67,86,87]. However, adherence to treatment regimens is challenging over the long term, as demonstrated by poor compliance rates in HIV and other chronic conditions.

In Canada, estimates suggest that approximately 11-19% of PWH are not fully adherent to their ART regimen [88]. ART adherence determinants are diverse and can vary across populations and

regions [71,89-94]. They include individual-level determinants such as complex medication regimens, side effects of ART, and mental health issues (e.g., depression and substance use) [71,89-93,95]. Individual beliefs, attitudes, and knowledge about HIV and ART can also influence adherence [93,96-98]. Moreover, social determinants of ART adherence include poverty, homelessness, and limited access to healthcare services, as well as stigma and discrimination in healthcare and community settings [93,94,99], which can impact the willingness of PWH to seek and continue care [93,94,99]. Systemic determinants include the quality and accessibility of healthcare services, financial assistance for ART and other healthcare-related expenses. They also encompass social support and peer networks [93,94,99,100,101]. These issues may impact an individual's ability to manage the demands of taking ART on a daily basis.

Increasing patient adherence levels to ART regimens has been repeatedly emphasized since the introduction of potent yet "unforgiving" treatments in the mid-1990s [75,102-104]. Since then, adherence to ART remains a complicated and ongoing challenge in the care of PWH in Canada, impacting their health outcomes and the emergence of drug-resistant strains of the virus.

To address this issue and enhance adherence rates, a comprehensive and tailored approach that considers individual, social, and systemic factors influencing adherence is crucial [26]. This approach should encompass measures such as simplifying medication regimens, providing support for managing side effects, and addressing social and economic barriers to care.

In Canada, several initiatives are underway to support adherence to ART, including programs that provide peer support, financial assistance, and access to healthcare services. Additionally, telemedicine and mobile health technology are being explored as innovative approaches to support adherence and improve access to care for PWH [26,105].

Building upon the initiatives in place to support adherence to ART and counseling PWH in Canada, it is imperative to recognize the essential role that pharmacists play in HIV care [106,107].

Essential Role of Pharmacists in HIV Care

Pharmacists play an influential role in healthcare [106,107]. Canadian pharmacists' roles are constantly expanding with changes in the profession [108,109]. Their expertise and services cover a wide range of healthcare needs, including medication reviews, independent prescribing, adapting prescriptions, chronic disease management, and vaccinations, varying from one province to another [110-112]. These services can improve patient health outcomes, as studies have shown that pharmacy services positively improve clinical outcomes and reduce healthcare costs

[113,114]. However, recently there has been a shift in the focus of pharmacists, moving away from solely providing medication supply towards a patient-centered approach, prioritizing the needs and well-being of the patient [115].

This evolution has been influenced, in part, by the medication dispensing technology advances facilitating the distribution process and minimizing the necessity of pharmacists in the process [116,117]. These technological advances have allowed pharmacists to focus more on providing appropriate medication therapy management [118-120]. Thus, pharmacists have become established and essential members of the healthcare delivery team, emphasizing their roles in patient-centered care [121,122].

Pharmacists are considered the healthcare professional most accessible to the public and the first point of contact for patients seeking medical treatment [30-33,109,115,123,124]. "Community pharmacy, also known as a retail pharmacy, is the most common type of pharmacy that allows the public access to their medications and advice about their health" [34]. For instance, many patients seek advice from pharmacists before consulting a physician about non-emergency conditions [125-128].

Pharmacists play an essential role in the management of HIV in Canada, as they are often the first and most regular point of contact for PWH seeking healthcare services [29,36,37,129-132]. Pharmacists are accessible healthcare providers who practice in an environment that supports HIV treatment and prevention services [29,36,37,129-132]. Pharmacies provide healthcare in a non-stigmatizing and accepting environment. They also offer more flexible hours and closer proximity, making pharmacists and pharmacies optimal partners in HIV care [129,132,134-136]. For instance, studies have found that consumers favor HIV screening and monitoring services in community pharmacies and feel comfortable with pharmacists providing HIV services to them [35,137-140].

Pharmacists' knowledge of drugs and clinical skills can help with patient interactions through education and counseling [34,141-145]. Pharmacists are well-equipped to help with the current and future challenges of HIV care, including helping to deliver comprehensive primary care to the patient population of PWH and identifying long-term complications associated with HIV infection and ART [29,129,130,133,146,147].

As HIV care continues to evolve, pharmacists must extend their roles to identify and meet the needs of PWH in the future. Pharmacists' primary responsibilities include patient education and medication counseling, compounding, checking, and dispensing prescription drugs to patients

accurately and legally [36,148-153]. Therefore, pharmacists are required to possess specialized education, skills, and competence to provide services to the community [34,154,155].

Pharmacists can provide education to patients about medication-related care, assessing the patient's willingness and ability to adhere to ART regimen, providing initial or follow-up counseling on HIV-related disease and complications as well as ART medications, and evaluating adherence to a therapeutic regimen [36,37,134,142,156-158]. Every patient encounter should involve discussions about medication indication, dose, route, frequency, potential adverse effects, and the importance of medication adherence [36,37,159,160]. Medication understanding and adherence should be evaluated for ART drugs and all medications among returning patients [36,66,161-164]. Pharmacists can help ensure successful pharmacotherapy, compliance, and treatment outcomes by educating patients [64,142,165-171].

Among the tools pharmacists can provide to help patients adhere to therapy are counseling (e.g., one-on-one adherence, disease and education counseling), reminder tools (e.g., prescription refill reminders and medication planners), adherence packaging (e.g., blister packs), and advice on how to handle medication side effects [129,142,168-175]. In addition to facilitating access to medications, pharmacists can help PWH adhere to ART by coordinating prescription refills, linking them with medication cost-saving programs, and assisting them with health insurance-related issues [129,176]. Pharmacists can identify PWH who need adherence support by routinely reviewing prescription refill histories to ensure that ART prescriptions are being filled [129,159,171,175,177]. When pharmacists identify non-compliant patients, they can tailor adherence interventions to each patient with a gap in their refill history [134,171,178,179,180]. Pharmacists can also use this data to inform primary care providers about the need to implement adherence interventions with their patients [163,171,181-184].

Pharmacists may also provide medication therapy management (MTM), an interactive, two-way dialogue with the patient (in contrast, traditional counseling is typically a one-directional conversation) [305,306,307,308,309,310]. As part of this two-way discussion, a pharmacist interviews the patient to gather information about the patient's medical history and medication concerns [185-190]. MTM allows pharmacists to identify medication-related problems and develop a plan to address them [185-190]. This plan may include referring the patients to their healthcare provider, collaborating with the healthcare provider to resolve problems, or working directly with the patient. Pharmacists' use of MTM programs has been shown to improve health

outcomes and overall costs for chronic diseases such as hypertension, diabetes, and asthma. It also improves ART adherence and decrease contraindications in HIV treatment [191].

Due to the extended roles of pharmacists, especially in the community setting, getting more involved in direct patient care, such as patient counseling, the need for pharmacists to provide accurate information promptly becomes increasingly important [192]. To effectively perform this role, pharmacists require access to up-to-date information on ART and the management of HIV, as well as specialized training and continuing education in the area of HIV care [193].

Pharmacists' Need to Stay Current on HIV Care despite the Difficulties

Canadian pharmacists have a professional obligation to provide the best possible care to their patients, and staying current on the latest developments in HIV care, treatment, and adherence is crucial to fulfilling this obligation. This up-to-date knowledge is essential for effectively counseling PWH and providing them with accurate guidance.

However, counseling PWH can be a challenging task for Canadian pharmacists due to several factors. These include a lack of HIV-related training and knowledge [194,195], time constraints [139,196,197], difficulty finding accurate and reliable sources of information [139,197-199], and trouble accessing this information quickly and with language that can be easily understood by PWH [199-201]. These challenges can potentially lead to misunderstandings and the provision of incorrect information.

To overcome them, pharmacists must actively seek opportunities for continuing education and professional development. For instance, peer-reviewed journals serve as valuable resources, providing in-depth analysis of research and practical insights into HIV care [199]. Participation in continuing education programs, such as online courses and conferences, can also enhance pharmacists' knowledge and understanding of HIV care and treatment [199]. In addition, professional associations, like the Canadian Pharmacists Association, offer access to clinical guidelines, patient education materials, and expert consultants to support pharmacists in delivering quality care to PWH [199].

Despite the availability of these resources, accessing and extracting relevant information may require additional time and resources [139,196,197]. There is a need for simplified and easily understandable information on HIV care that can be effectively communicated to the public [202]. Additionally, addressing the stigma and discrimination faced by PWH is crucial to fostering a supportive environment that encourages seeking care and sharing health information [203,204].

Developing appropriate resources and educational materials to address and prevent stigma is essential to ensure effective counseling and support for PWH. Many PWH may be hesitant to seek care or to share information about their health status due to stigma and discrimination [203,204]. Stigma can make it difficult for pharmacists to build rapport with PWH and provide effective counseling.

Pharmacists' Use of Digital Technology in Healthcare

Pharmacists have embraced digital technology to enhance their practice and improve patient care. Digital technology includes mobile health (M-health) and electronic health (E-health), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine. It can assist pharmacists in tasks related to medication management, patient education, medication reconciliation, and communication with other healthcare providers, ultimately aiming for reducing inefficiencies, improving access, reducing costs, increasing quality, and making medicine more personalized for patients [205,206].

Numerous studies have been conducted to explore the role of telehealth and digital technology use by pharmacists in addition to their impact on health outcomes [207-226]. These studies focused on telecommunication between pharmacists and patients and the use of social media and mobile applications for public health interventions or medication counseling and adherence to treatment in chronic conditions.

Although patients and pharmacists demonstrated satisfaction regarding the use of digital technology [227], digital literacy and the digital divide represent challenges for both populations. Studies show that those who use these digital tools in their personal lives are more likely to use them in their daily work routines [207,208].

Pharmacists especially leverage M-health applications in their professional lives [206]. These applications encompass functionalities such as patient-pharmacy interfaces for online prescription ordering, access to dispensing history, medication reminders, medicines information, quality use of medications advice, direct messaging, online chat with pharmacists, and online commerce. Additionally, professional pharmacy bodies endorse and recommend applications that enable pharmacy locator services, the recording of patient consultations, access to patient medical history, quality management systems, and membership services. Furthermore, applications developed by the pharmaceutical industry and reference resources for pharmacists, can include drug information,

clinical calculators, guidelines, academic literature databases, continuing education programs, diagnostic support tools, medicines availability, and patient information repositories [206].

Traditionally, formularies and other clinical reference texts have existed primarily as printed resources [206]. With the availability of the internet and reference texts or drug resources on mobile devices, pharmacists now have access to trusted and reliable clinical medical references and drug databases at the point of patient care on their personal tablets, smartphone, laptop, or their workplace desktop computers [206]. These internet-based tools typically include functions to search for drug indications, dosages, contraindications, interactions, adverse drug reactions, and other health information [206].

Although healthcare providers depend on various internet-based tools while looking for reliable health-related information, they may be overwhelmed by the vast amount of available data. These tools include medical databases, websites, and applications; however, lately, chatbots have been shown to provide more simple, affordable, available, and human-like methods to retrieve information [228]. With AI and natural language processing (NLP), chatbots could compete with several mobile apps and even replace some, as they can understand users' questions and respond appropriately to them [228,229].

Transforming Healthcare with AI Chatbots: the Future of Digital Health

Chatbots – known as "conversational agents" – are computer programs designed to simulate conversation with human users through websites, messaging platforms, or computer software via texts, images, links, sounds, and videos on computers or cellphones [228-252]. Chatbots come in different forms, including text, voice, or/and human-like avatars, utilizing AI or non-AI predefined scenarios. They have been applied in various markets across different industries, such as education, e-commerce, finance, news, healthcare, and entertainment. Examples of these applications include eBay's ShopBot and Amazon's Alexa [253], CNN's Chatbot, immigration virtual assistants, call center virtual representatives, Facebook Messenger chatbots, and personal assistance (e.g., Apple's Siri [254], Google Assistant [255], Microsoft's Cortana [256], and Samsung's Bixby [257]). Interestingly, the term 'Chatbot' itself is a derivative of the original term 'ChatterBot,' which was first coined in 1994 [258].

In recent years, advances in digital health technology have fostered innovations in healthcare, resulting in less expensive, more efficient, and better-quality care [259-263]. Chatbots are among the promising solutions, given their broad spectrum of uses and acceptability. The use of chatbots

to access and deliver healthcare services is on the rise, granting them multiple potential roles in preventing, diagnosing, and providing help with treatment, ultimately impacting the whole healthcare system. In healthcare, the first identified chatbot called "ELIZA" was created in 1966, imitating a psychotherapist in a text-based form [264]. ELIZA was developed aiming to pass the Turing test, a test showing that a computer program can impersonate a human in a real-time written conversation with a human judge so well that the judge cannot reliably separate the program from a real human based on the conversational content alone [253,265]. Upon passing the Turing test, the chatbot was considered intelligent. ELIZA was less sophisticated than current chatbots, but it sparked the interest of researchers in developing chatbots over time, such as PARRY in 1975 [266] and Dr. Sbaitso in the early 1990s [267].

Chatbots really gained traction in the last two decades with the advances in AI algorithms in digital healthcare. Various applications of AI in healthcare encompass the accurate and automated diagnosis of disease prediction, remote patient monitoring and treatment, access to emergency services with no time, and AI therapy [268,269]. The AI represents the capability of algorithms for machines to estimate the concluding results without human intervention [269]. Therefore, AI provides smart ways to increase the life expectancy of patients with chronic conditions and ensures healthy living [269]. The advances in AI have reshaped health chatbots – particularly, their ability to respond to users' different demands and establish an emotional bond with users [270] – by meeting their need for communication, affection, and social belonging.

Using advanced AI methods (NLP and machine learning algorithms) to understand users' requests and respond appropriately, AI-based chatbots can provide relevant information on various topics via texts, images, sounds, and videos and learn from interactions to improve over time [271,272]. The use of chatbots in healthcare is becoming increasingly prevalent as technology continues to advance and the demand for accessible, convenient, and personalized healthcare services increases.

To inform the design of a chatbot adapted to pharmacists' needs and preferences in HIV care (MARVIN-Pharma), a rapid review of literature on the roles, users and benefits of chatbots in healthcare is necessary to:

- Understand the current landscape: It is essential to have a comprehensive understanding of the current use of chatbots in healthcare and their roles and benefits. This will provide a

foundation for designing and implementing a chatbot specifically adapted to pharmacists' needs and preferences in HIV care.

- Identify gaps and opportunities: The review can locate areas where chatbots have succeeded in healthcare and where they may have fallen short.
- Inform the design of MARVIN-Pharma: This review can provide valuable information on the features and functionalities that are most important to pharmacists in HIV care. This can help maximize the chatbot's utility and effectiveness in assisting them with counseling PWH and answering their questions.
- Ensure evidence-based design and implementation: The review will provide evidence-based insights into the design and implementation of chatbots in healthcare, helping to ensure MARVIN-Pharma's effectiveness.

Chapter 2 (Manuscript 1):

Rapid Review of Roles, Users, and Benefits of Chatbots in Healthcare

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Abstract

Introduction: Chatbots – "conversational agents" – are computer programs designed to mimic conversations with human users. Chatbots are gaining traction with recent advances in artificial intelligence (AI) algorithms and their application in digital healthcare.

Aim: To address knowledge gaps about chatbots used in healthcare, specifically as to their roles, the populations they reach, and their benefits.

Methods: A rapid review was performed. A search strategy was developed with a health science librarian and performed in Medline and Embase databases. Two reviewers dual-screened the search results. We included primary research studies reporting data on chatbot roles and/or benefits for the healthcare system. Data extracted on chatbot roles, users and benefits were submitted to content analysis.

Results: We identified seven categories of chatbot roles: 1. remote consultation and treatment advice; 2. education and skills-building; 3. health behavior promotion; 4. self-management and monitoring; 5. remote triage; 6. health-related administrative tasks; 7. research purposes. Six categories of chatbot users were identified: 1. chronic and/or older patients; 2. healthy adults and

the general population; 3. women; 4. populations with mental health issues; 5. children; 6. healthcare professionals and students. We recognized six benefits for the healthcare system: 1. promotion of health equity; 2. improvement of healthcare quality; 3. promotion of patient-centered care; 4. relief of administrative or clinical burdens; 5. assessment of a public health situation; 6. making the best use of the collected data.

Conclusion: The wide range of uses and effects of health chatbots position them as promising enablers for more efficient quality of care.

Keywords

Chatbot, conversational agent, conversational assistant, embodied conversational agent, user-computer interface, digital health, mobile health, electronic health, telehealth, telemedicine, artificial intelligence

2.1 Introduction

Chatbots – known as "conversational agents" – are computer programs designed to simulate conversation via text, image, audio, or video messaging with human users on platforms such as websites, smartphone applications, or computer software [1-25]. The term 'Chatbot' is a variation of the original term 'ChatterBot' first mentioned in 1994 [26]. Chatbots utilize advanced artificial intelligence (AI) methods to understand users' requests and respond appropriately [27, 28], or non-AI predefined scripted conversation scenarios, to provide information on various topics. They have been applied in various markets across different industries, such as education, e-commerce, finance, news, healthcare, and entertainment. More commonly known examples of these applications include eBay's ShopBot, Amazon's Alexa [29], CNN's Chatbot, Apple's Siri [30], Google Assistant [31], Microsoft's Cortana [32], and Samsung's Bixby [33].

In recent years, advances in digital health technology have been increasingly perceived as a way to foster innovations in healthcare, which could result in less expensive, more efficient, and better-quality care [34-38]. Chatbots are one such promising tool, given their broad spectrum of uses and their acceptability [39, 40]. The use of chatbots to access and deliver healthcare services appears to be on the rise [25, 41-43], granting them multiple potential roles in prevention, diagnosis, and support with care and treatment, with possible impacts on the whole healthcare system.

Moreover, chatbots are really gaining traction with recent advances in AI algorithms and their application in digital healthcare. Several published reviews described the use of chatbots or

assessed their effectiveness [5] in: mental health [4,8,12,13,14,15,16,17], the promotion of healthy lifestyles [2,18,19], the self-management of chronic conditions [6,20,9,21], oncology [9,11], and health education and training [22], in addition to the personalization of conversational agents [23]. Other studies focused on chatbots' language and other technical aspects [24,25]. Algorithms allow machines to estimate results without human intervention [44], and their application in healthcare-related AI opens possibilities for increasingly accurate and automated diagnoses based on probabilities, including, for example, remote patient monitoring and treatment and instant access to key and tailored services, as well as AI-based interventions [44,45]. Furthermore, these technological advances have refined health-related chatbots, in particular their ability to respond to specific types of users in terms of sociodemographic characteristics and also in terms of their non-medical needs, including, for example, their need for communication, affection, and social belonging [14,46-48]. Chatbots could thus be adaptable to key populations, including marginalized groups and minorities [4, 49], and contribute to the tailoring of services, fostering more patient-centered care [23].

A systematic review [3] has explored the application of conversational agents within the realm of healthcare. Despite the comprehensive examination of the conversational agents' characteristics and the evaluation measures utilized (such as technical performance, user experience, and health research metrics), the scope of the review was limited, as it only incorporated a minimal number of studies (17) [3]. Another recent study [7] reviewed the characteristics, content, and evaluation of chatbots in healthcare. However, it focused mainly on evaluating chatbots and omitted publications that simply reported on their use without assessment. It also excluded animated and embodied conversational agents (ECA) and did not review the reported benefits or targeted users of chatbots with regards to the chatbots' use in healthcare. Our review thus aims to address these knowledge gaps about chatbots used in healthcare, specifically as to their functions or roles, the populations that they reach, and their benefits.

2.2 Methods

2.2.1 Design and search strategy

This study is a rapid review, which refers to an accelerated, resource-efficient process of knowledge synthesis through streamlining or omitting specific methods associated with more traditional review processes [50,51]. Hence, a rapid review assesses what is already known in a given area within a relatively short time.

Table 1 describes our search strategy. This strategy was developed with a health science librarian (Table 1) and performed in the Medline and Embase databases on February 5th, 2022, and updated on April 22nd, 2022. The strategy also included searches within reference lists and websites (e.g., Google Scholar) for relevant material. We exported our search records to Endnote.

Table 1. Search strategy

Search terms
1. user-computer interface/ or (Chatbot* or chat bot* or User-Computer Interface* or (conversational adj2 (agent* or assistant*)).mp
2. Limit 1 to (conference paper or adaptive clinical trial or case reports or clinical conference or clinical study or clinical trial, all or clinical trial, phase i or clinical trial, phase ii or clinical trial, phase iii or clinical trial, phase iv or clinical trial or comparative study or controlled clinical trial or equivalence trial or evaluation study or multicenter study or observational study or pragmatic clinical trial or randomized controlled trial)
3. Limit 2 to yr = "2017 - Current"
4. Limit 3 to English

2.2.2 Study selection

We included primary research studies using a text- or voice-based chatbot as an intervention or way to deliver an intervention and reporting original data on one or more of the following: chatbot uses, roles or functions in healthcare settings or their reported strengths or potential benefits for the healthcare system.

We limited our search to records published in English (as suggested by Cochrane rapid reviews guide) [52] from 2017 to 2022. This time limit was set because different searches with different time limits showed that the largest number of articles was published in the interval used in our study, and we also wished to favor the inclusion of chatbots with more recent technology. We did not have limits for the study population.

We excluded studies not meeting the inclusion criteria, as well as studies reporting: engineering or computer science data; pre-intervention data about future initiatives such as protocols; only nonbehavioral actions such as gestures and face expressions-based avatars without text or voice interaction; conversations with an actual robot (not a conversational interface); and virtual reality chatbots. We also excluded conference abstracts with insufficient details.

2.2.3 Data extraction and synthesis

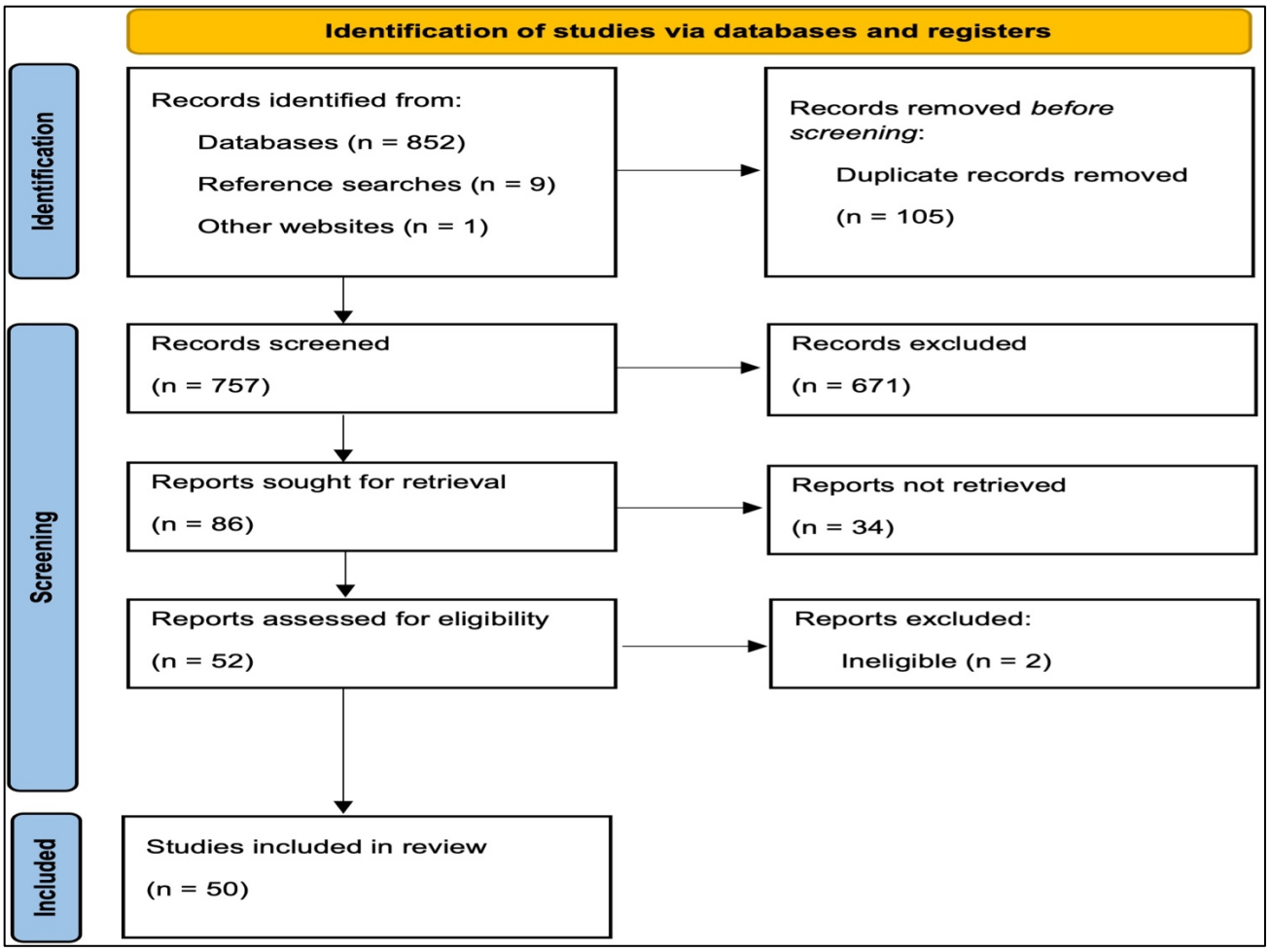
Two reviewers (ML, YM) dual-screened 15% of titles/abstracts and full-texts to calculate percent agreement and interrater reliability with Cohen's Kappa [53]. Discrepancies were discussed. ML performed all other screenings. Using Microsoft Excel, we extracted the studies' data and characteristics (e.g., title; authors; month and year; journal; study design; chatbot users; the chatbot's medical specialty; chatbot design: whether or not it uses AI or is animated; country of origin; as well as the reported roles of chatbots; and benefits to healthcare). Data extracted on chatbots' roles, users and benefits were submitted to content analysis to generate categories and overarching themes [54]. Our rapid review is compliant with the PRISMA statement, as illustrated in Figure 1 [55].

2.3 Results

2.3.1 The database searches

Our search generated a total of 852 records, of which 105 were duplicates, leaving 757 for title/abstract screening. Of these, 86 full texts were reviewed [56-105] (Figure1). Percent agreement among the reviewers was 94.3% for the full-text review. Interrater reliability was 64–81%, and Cohen's Kappa was 0.88, indicating strong agreement [41]. We included 50 studies reporting the roles and/or benefits of chatbots. In all, (49/50; 98%) articles discussed chatbot roles and (48/50; 96%) articles discussed chatbot benefits.

Figure 1. Search PRISMA flowchart



2.3.2 Origins of the included studies

Almost half of the studies originated from the USA (n=21; 42%). Five (10%) came from Switzerland, one of which was led in multiple countries (Austria, Germany, and Switzerland). Four (8%) were from Japan. Australia (6%) and Korea (6%) each had three studies, while France (4%), Italy (4%), New Zealand (4%), and the United Kingdom (4%) were represented by two studies each. Finally, one study (2%) came from each of the following countries: China, Portugal, Russia, Singapore, Spain, and Sweden.

Out of these, four (8%) from the USA pertain to a single chatbot, while another four (8%) from the same country investigate the same chatbot. Additionally, two (4%) from Australia investigate the same chatbot, and two (4%) from Korea also focus on the same chatbot. Furthermore, four (8%) from Switzerland examine the same chatbot, and two (4%) studies from New Zealand also investigate the same chatbot.

2.3.3 Characteristics of the chatbots

In all, twenty-eight (56%) studies reported using artificial intelligence (AI)-based chatbots, 11 (22%) used non-AI chatbots, and 11 (22%) studies did not provide this information. Eight studies (16%) reported using instant messaging app-driven chatbots. Seventeen (34%) indicated using embodied conversational agents; 13 chatbots (26%) represented virtual healthcare providers, and four chatbots (8%) represented virtual patients for medical education.

2.3.4 Chatbot roles

Most studies (n=49; 98%) stated the actual role(s) of the chatbot utilized. Our analysis yielded twenty sub-categories of primary roles (in single quotations), grouped into seven categories, which were organized into two overarching themes, summarized in Table 2.

Theme 1: Delivery of remote health services. This theme refers to health services offered remotely as an alternative to usual on-site modes of delivery. It includes five categories of roles, with forty-six studies (92%) contributing to this theme.

Remote consultation and treatment advice

This category refers to the facilitation of medical consultations or the delivery of advice or support. Of all, 31 studies (62%) contributed to this category. Among these, 16 (32%) reported providing 'consultations with interviews or counseling sessions' through chatbots. The other six studies (12%) discussed using chatbots to provide 'treatment advice'. An additional 13 studies (26%) reported providing 'mental health support' via chatbots.

Education and skills-building

This category includes the dispensation of educational material or medical information, or skill development material for users (e.g., exercising, using a medical device), including for patients, healthcare providers, or medical students. In all, 28 studies (56%) contributed to this category. Four (8%) reported using chatbots in 'medical education and clinical skills for healthcare providers and medical students'. An additional role was to promote the 'health literacy' of the targeted population, as discussed in 24 studies (48%), of which seven (14%) reported using the chatbot for 'psychoeducation' to enhance mental wellbeing.

Health behavior promotion

This category includes the promotion of healthy lifestyles, e.g., physical activity, healthy diets, or stress management. With 19 studies (38%) contributing to this category, 'healthy lifestyle behavior' was encouraged in 12 (24%) through the chatbot. Health behaviors refer to people's actions to enhance or maintain their health, and healthy lifestyle behaviors refer to habits related to personal goals. These studies described enhancing a healthy lifestyle as the primary role of the chatbot or as an adjunct intervention to improve other health outcomes associated with chronic conditions. In addition, all contributing studies (38%) discussed 'applying behavioral change theories or models in healthcare' through chatbots.

Self-management and monitoring

This category includes chatbot use to improve the ‘self-management or monitoring’ of specific health conditions, either to avoid complications and hospitalization or to track changes in health status. Sixteen studies (32%) reported using a chatbot for this purpose. More specifically, 13 (26%) reported 'self-management for chronic conditions' that require self-care and monitoring for a longer duration. This included identifying early health concerns to avoid complications or rehospitalization. One study (2%) reported 'self-care and monitoring for COVID-19'. Another (2%) reported 'self-monitoring for health behavior change'.

Remote triage

This category includes the screening or assigning of patients to different risk categories and their referral to different clinics, based on patients' provisional diagnosis or the determined urgency or risk level. Fourteen studies (28%) discussed using chatbots for triaging patients' complaints. Among these, seven (14%) reported chatbot use for 'triaging, screening, and risk assessment'. An additional two studies (4%) discussed their use for 'provisional diagnosis'. A further six studies (12%) described a chatbot-based 'self-administered questionnaire' to assess patients' complaints and identify potential risks or complications. Finally, four (8%) reported chatbot roles in 'referral' or recommending a specific specialty or specialized clinic to visit.

Theme 2: Provision of administrative assistance to healthcare providers. This theme refers to all types of administrative work done by the chatbots, including two categories: health-related administrative work and research purposes, with nine studies (18%) contributing to this theme.

Health-related administrative tasks

This category includes the completion of healthcare providers' routine administrative work, such as data collection, entry, or transferring data to patients' medical history and records. In all, six studies (12%) reported using the chatbot for 'data collection and storage in patients' charts' in the electronic medical records as well as to patient-reported outcome data, which could be captured by chatbots to replace collection by healthcare providers.

Research purposes

This category includes the completion of research-related work such as participant recruitment, the consent process, or data collection through surveys. Three studies (6%) contributed to this category. In two, the 'recruitment' of research study participants was reported using a chatbot. One of these (2%) discussed chatbot use to obtain 'e-consent' from individuals to participate in the study. An additional study (2%) reported 'data collection through a self-administered questionnaire for research purposes'.

Table 2. Roles of the chatbots (n=49; 98%)

Theme	**Category**	**Sub-category**	**Number and percentage of studies**
Delivery of remote health services	**Remote consultation and treatment advice**	Consultations with interviews or counseling sessions	16/50; 32%
		Mental health support	13/50; 26%
		Treatment advice	6/50; 12%
	Education and skills-building	Health literacy	24/50; 48%
		Psychoeducation	7/50; 14%
		Medical education and clinical skills for healthcare professionals and medical students	4/50; 8%
	Health behavior promotion	Applying behavioral change theories or models	19/50; 38%
		Healthy lifestyle behavior	12/50; 24%
		Self-management and monitoring	16/50; 32%

	Self-management and monitoring	Self-management for chronic conditions	13/50; 26%
		Self-care and monitoring for COVID-19	1/50; 2%
		Self-monitoring for health behavior change	1/50; 2%
	Remote triage	Triaging, screening, and risk assessment	7/50; 14%
		Self-administered questionnaire	6/50; 12%
		Referral	4/50; 8%
		Provisional diagnosis	2/50; 4%
Provision of administrative assistance to healthcare providers	**Health-related administrative tasks**	Data collection and storage in patients' charts	6/50; 12%
	Research purposes	Recruitment	2/50; 4%
		e-consent	1/50; 2%
		Data collection through a self-administered questionnaire for research purposes	1/50; 2%

2.3.5 Chatbot users

All 50 studies specified the type of health population they targeted — chatbot users. The content analysis yielded 15 sub-categories of chatbot users (in single quotations), grouped into six broader categories of users, summarized in Table 3.

Chronic and/or older patients. In all, 14 studies (28%) targeted patients living with chronic conditions or older patients. Ten (20%) catered to 'patients with chronic health conditions', including patients with type-2 diabetes (4%), hypertensive adults (2%), and patients with irritable bowel syndrome receiving cognitive behavioral therapy (2%). Another study (2%) targeted pediatric asthmatic patients. For research recruitment, one study (2%) focused on adults with pulmonary disorders at a minority-serving institution. Three studies targeted people with chronic pain (6%); one (2%) with adults suffering from any type of chronic pain; another (2%) focused on workers suffering from chronic musculoskeletal pain; and an additional study (2%) involved adults

presenting with orthopedic trauma who underwent operative fixation of a traumatic upper or lower extremity fracture, to reduce early postoperative opioid utilization for postoperative pain.
Five studies (10%) addressed chatbots targeting the 'older population', in particular, geriatric patients who were exposed to elder mistreatment and others who were prone to social isolation, especially during the COVID-19 pandemic (4%). An additional study (2%) recruited underserved insufficiently active Latin adults aged 50 years or older, while yet another study (2%) focused on individuals older than 50 years experiencing a problem that caused emotional distress with no other diagnosis of mental health disorder.
One study (2%) included patients who were both chronic and older than 50 years and discussed two case studies of patients, one with chronic heart failure and one with chronic obstructive pulmonary disease.

Healthy adults and the general population. Twelve studies (24%) targeted this type of users. Six studies (12%) focused on 'healthy lifestyle and health behavior change-seeking population'; one (2%) recruited clients from a health insurance company; another (2%) concerned well-educated adults with a sedentary lifestyle and poor dietary habits; another (2%) recruited employees whose work was performed in an office or another administrative setting; another (2%) included participants aged above 21 years without a chronic condition that could limit their physical activity or exercise; another (2%) centered on university undergraduates with no specific diet (e.g., veganism or vegetarianism); and another (2%) involved inactive adults. One study (2%) recruited healthy adults interested in a psychological intervention who are not involved in any other psychological treatment for 'mental health or wellbeing'.
Four studies (8%) involved 'general population', three (6%) were large-scale, engaging over 16,000 participants each; one of these (2%) aimed to assess the COVID-19 public health situation. Another large-scale study (2%) recruited participants from Facebook-/targeted advertisements and a university campus.

Women. Seven studies (14%) targeted women. Five studies (10%) involved women of fertile-age in 'gynecology patients'; three of which (6%) focused on black African Americans, and one (2%) on a racially diverse population.
Two studies focused on women living with cancer ('oncology patients'); one study (2%) concerned women with breast cancer, and another (2%) with women at risk of hereditary cancer.

Populations with mental health issues. In all, eleven studies (22%) targeted patients with mental health conditions. In order of frequency, the mental health populations represented were: those with 'substance use disorder' (n=4 studies; 8%), adults receiving 'mental health' interventions (n=11 studies; 22%), adults at greater risk of developing mental illness during the COVID-19 pandemic (n=1 study; 2%), adults interested in psychological intervention who are not receiving any other psychological treatment (n=1 study; 2%), young adults (age 18-29 years) recruited within 5 years of completing active cancer treatment (n=1 study; 2%), adults diagnosed with panic disorder with or without agoraphobia (n=1 study; 2%), gamblers not receiving any other mental health support (n=1 study; 2%), participants reporting significant attention problems (n=1 study; 2%), adults in a relationship (n=1 study; 2%), adults diagnosed with insomnia (n=1 study; 2%), patients with depression and anxiety symptoms (n=1 study; 2%), patients with irritable bowel syndrome who were receiving cognitive behavioral therapy (n=1 study; 2%), and elderly with emotional distress (n=1 study; 2%).

Children. Among all, two studies (4%) targeted pediatric patients (children). One (2%) included children aged 10-15 years 'with asthma'; another (2%) focused on 'overweight' children aged 10-18.

Healthcare professionals and students. Four studies (8%) targeted healthcare professionals and students. These four studies involved healthcare providers and medical students. In order of frequency, the healthcare professionals and students populations represented were: healthcare professionals (n=2 studies; 4%), providers from a department of veterans' affairs and a department of defense medical facility (n=1 study; 2%), and 'resident physicians' and fellows (n=1 study; 2%) from university-affiliated training programs, 'medical students' (n=1 study; 2%), and 'nursing students' (n=1 study; 2%).

Table 3. Chatbot users (n=50 studies; 100%)

Category of targeted users	**Sub-category**	**Number and percentage of studies**
	Patients with chronic health conditions	10/50; 20%

Chronic and/or older patients	Older population	5/50; 10%
Healthy adults and the general population	Healthy lifestyle or health behavior change-seeking population	6/50; 12%
	General population	4/50; 8%
	Mental health well-being seeking population	1/50; 2%
Women	Gynecology patients	5/50; 10%
	Oncology patients	2/50; 4%
Population with mental health issues	Mental health patients	11/50; 22%
	Substance use disorder patients	4/50; 8%
Children	Asthmatic children	1/50; 2%
	Overweight children	1/50; 2%
Healthcare professionals and students	Healthcare professionals	2/50; 4%
	Resident physicians	1/50; 2%
	Medical students	1/50; 2%
	Nursing students	1/50; 2%

2.3.6 Chatbot benefits

Most studies (n=48; 96%) described the benefits of using chatbots in healthcare. The content analysis yielded 18 different sub-categories of benefits (in quotation marks), grouped into six categories, which relate to two broad themes, summarized in Table 4.

Theme 1: Improvement of healthcare standards. This theme refers to the processes of enhancing the quality, personalization, and accessibility of healthcare services delivered to targeted chatbot users. It includes three categories of benefits contributing to this theme.

Promotion of health equity

Thirty-one studies (62%) reported the promotion of health equity as a benefit. Health equity refers to minimizing disparities and inequality based on social determinants of health, including differences between groups in terms of socioeconomic factors, gender, and ethnicity [106].

Nine studies (18%) described using the chatbot as a 'nonjudgmental' intervention, helping users to disclose sensitive personal information. Another five studies (10%) reported the chatbot as a health

tool to 'reduce stigma' in healthcare settings, specifically, the stigma associated with seeking mental health care or being a member of an ethnic minority. Moreover, 17 studies (34%) discussed using a chatbot as a potential tool to 'increase care accessibility and availability' by providing services for minor health concerns that do not require emergency visits 24/7, in particular for marginalized groups (e.g., black women and older users) and people with low technological literacy.

Improvement of healthcare quality

Twenty-seven studies (54%) reported enhanced healthcare quality or satisfaction; improved patient engagement in care, treatment adherence, health outcomes, or health literacy; and/or increased clinical or communication skills among healthcare professionals or medical students.

Eight studies (16%) reported an 'enhanced adherence rate' to treatment or a health intervention, and 19 studies (38%) discussed improved results, including 'positive health outcomes, knowledge, and skills'.

Moreover, six studies (12%) reported 'improvement in patient-healthcare professional communication'. Two studies (4%) integrated communication between both healthcare professionals and patients through the chatbot, and three (6%) introduced a chatbot module for communication skills to improve medical education for healthcare professionals and medical students.

Four studies (8%) using chatbots for medical education had an animated virtual patient for 'improving clinical knowledge and skills', as well as communication skills, by exposing medical students to complicated case scenarios that are hard to deliver through real patients or actors.

Promotion of patient-centered care

Among all studies, 31 (62%) reported benefits for the customization of interventions and enhanced patient-centered care either through tailored messages as a 'personalized intervention' or for fostering 'empathy, care, friendliness, and sympathy' in care. Patient-centered care refers to addressing patients' particular healthcare needs and concerns, improving the quality of personal, professional, and organizational relationships, and helping patients to participate more actively in their own care [107,108].

Twenty-six studies (52%) included in this category described each chatbot as a 'personalized intervention' providing tailored content to each user, based either on their present history or complaint, their past history, or both.

An additional ten (20%) discussed chatbots intended to enhance self-disclosure and users' engagement by emphasizing 'empathy, care, friendliness, and sympathy' in care.

Theme 2: Making work more efficient. This theme refers to using a chatbot as a health tool to provide efficient care for targeted chatbot users. Providing efficient care means producing the desired results with minimal or no waste of time, costs, materials, or personnel [109]. Three categories of benefits contributed to this theme.

Relief of administrative or clinical burdens

In all, 21 studies (42%) indicated reduced administrative or financial burdens for the healthcare system.

These studies mentioned that chatbots could potentially help relieve the burden of managing chronic health conditions in overwhelmed primary care settings. Three (6%) indicated that chatbots could 'reduce the number of unnecessary visits' to healthcare settings. Three studies (6%) reported potential 'relief of healthcare staffing shortage', and six (12%) indicated possible 'decreased workload' on healthcare professionals either by easing their workflow or helping them gain insights into their patients' data and reducing prescription and paperwork errors. The 'time-saving' utility of chatbots was mentioned in seven studies (14%). An additional 14 studies (28%) presented chatbots as a 'cost-saving' remote health intervention, especially compared to other routine interventions.

Assessment of a public health situation

Three studies (6%) mentioned possibilities to capture and assess large-scale public health situations, to provide evidence for researchers and policymakers.

One study (2%) discussed the significance of the data collected from users during the 'COVID-19 pandemic' to evaluate the public health situation, helping with decision-making by policymakers and public health authorities, in addition to researchers. Indeed, three studies (6%) were done on a 'population scale', indicating the feasibility of large-scale chatbot use.

Making the best use of the collected data

One study (2%) pointed out the benefits of making good use of the vast available health data in terms of collection and analysis. This study indicated the significance of using chatbots to 'employ the vast medical data to best serve health populations and healthcare professionals'. It showed that with big data, healthcare providers and administrators could drill down and learn more about their patients and their care. High-quality data collection in health care requires optimizing data collection tools and their proper use by patients and providers.

Table 4. Discussed benefits of the chatbots (n=48; 96%)

Theme	Category	Sub-category	Number and percentage of studies
Improving healthcare standards	**Promotion of health equity**	Increasing care accessibility and availability	17/50; 34%
		Nonjudgmental	9/50; 18%
		Reducing stigma	5/50; 10%
	Improvement of healthcare quality	Usability	27/50; 54%
		Positive health outcomes, knowledge, and skills	19/50; 38%
		Enhanced adherence rate	8/50; 16%
		Improvement in patient-healthcare professional communication	6/50; 12%
		Improving clinical knowledge and skills	4/50; 8%
	Promotion of patient-centered care	Personalized intervention	26/50; 52%
		Empathic, caring, friendly, emotional, or sympathetic	10/50; 20%
Making work more efficient	**Relief of administrative or clinical burdens**	Cost-saving	14/50; 28%
		Timesaving	7/50; 14%
		Decreased workload	6/50; 12%
		Avoid unnecessary visits	3/50; 6%

		Relief of healthcare staffing shortage	3/50; 6%
	Assessment of a public health situation	Population scale	3/50; 6%
		COVID-19 pandemic	1/50; 2%
	Making the best use of the collected data	Employ the vast medical data to best serve health populations and healthcare professionals	1/50; 2%

2.4 Discussion

This rapid review aimed to describe the roles, users, and benefits of chatbots in healthcare. The review underscored important gaps in the available literature, including the potential roles that chatbots can play, the populations they serve, and the benefits they can offer. These points will be addressed in the following section.

Chatbots in healthcare have been primarily studied in high-income countries, leaving untapped potential for addressing chronic conditions and enhancing health literacy in low-income countries

To better understand and interpret our results, we highlighted the general characteristics of studies, such as their country of origin. With 17 countries represented, the topic is clearly of global interest. However, 42% of included studies emerged from a sole country (the USA), and all other countries represented are of high or upper-middle-income [110]. No studies were conducted in low or lower-middle-income countries [110] where chatbots could provide a solution to the prevalence of chronic conditions and the constrained healthcare workforce [111] and contribute to increasing health literacy [112].

The potential to increase equity, accessibility, and empathy in care for underserved groups through the use of chatbots

The potential of chatbots in increasing access to healthcare is a crucial aspect that has been emphasized in our findings. In particular, chatbots have been seen as a promising solution to address equity in healthcare, especially for marginalized groups that are faced with distance, lack of mobility or literacy, and psychosocial vulnerabilities. These groups include children and teenagers, the elderly, young and older adults, individuals living with chronic or mental health

conditions, and people with sedentary lifestyles. The inclusion of these diverse user populations in the studies highlights the potential of chatbots to reduce stigma, link users to health services, and protect sensitive personal information [113], especially in the prevention and treatment of mental health conditions [114-116] and blood-borne and sexually transmitted infections [117].

Users have also appreciated the nonjudgmental and empathic nature of chatbots, as seen in their ability to maintain a friendly, caring, and emotional language [78,82,83,91,93,97-99,103], which is consistent with past literature testing the ability of humans to differentiate between empathic and less or non-empathic responses from chatbots [118-120]. Chatbots have been seen as particularly beneficial for users who are reluctant to receive healthcare services in-person due to confidentiality issues and prefer to access them online through a chatbot. Moreover, chatbots have been appreciated for their use of lay-friendly language, avoiding complicated medical terms, and providing better accessibility for people with various literacy or educational levels [103].

The increasing use of chatbots, especially in reaching marginalized and underserved groups, is in line with the democratization of smartphones and connected devices [121]. With over 80% of the population worldwide using smartphones and connected devices [122,123], chatbots have the potential to bridge the digital divide and increase access to healthcare for populations with low technological skills, such as the elderly, through their ease of use and minimal required technical skills, as seen in voice-based chatbots and embodied conversational agents [121].

Chatbots: promising for minor health concerns, but still doubtful for complex health issues

Studies also emphasized the broad availability (24/7) of chatbots to meet different populations' needs, such as those with minor health concerns or those asking for information outside physicians' work hours. However, the reviewed literature evaluates only usability and user experience without an in-depth assessment of the technical limitations of health chatbots [3,25] that may risk patients' health.

Therefore, it is recommended that further research be conducted to thoroughly assess the technical limitations of health chatbots and to ensure that they are equipped with the necessary tools and resources to accurately diagnose and manage complex health issues. In addition, it is important to evaluate the accuracy and reliability of chatbots in providing healthcare information, particularly for populations with major health concerns, to prevent any potential harm to their health.

Moreover, it is crucial to regulate the use of chatbots in healthcare and ensure that they are used ethically and responsibly. This includes implementing measures to protect users' privacy and sensitive information and ensuring that chatbots are transparent about their limitations and capabilities.

The roles of chatbots in relation to their potential benefits

While the included studies described a wide range of chatbot roles in healthcare, the delivery of remote health services (e.g., consultations, treatment advice), was most reported (62%). Education and skills-building was reported in over half (56%) of the studies, the second most reported role. The results of our study have documented the various roles that chatbots can play in healthcare, and have related these roles to the reported and potential benefits of chatbots in healthcare. In other words, the results have shown the ways in which chatbots can serve different purposes in healthcare, and how these purposes can result in specific benefits for users. Some studies reporting chatbot use for health education and delivering remote health services said that it could increase patient engagement and adherence to treatment, as reported by eight studies, and self-management, as indicated in 16 studies, avoiding unnecessary non-emergency visits, and saving time and resources. This agrees with past literature pointing out that patient engagement in care could be bolstered by enhancing their knowledge through education and health literacy [124]. The growing interest in patient education is driven by several key factors, including the need to promote patient adherence and engagement, to improve care at home [124], and to address the burden and cost of chronic conditions [124,125].

Past literature also reported that patient education provides patients with knowledge, skills, values, and attitudes related to particular or broad medical topics, preventive actions, choosing healthy lifestyles, understanding illness conditions and health-promoting behaviors, proper use of medications, and the care of illness and wounds at their place [124,126]. This also agrees with our results of reported roles of chatbots in health behavior change in 38% of the included studies. Other studies reported providing chatbot-delivered CBT for primary or secondary preventive care [57,60,61,68,73,78,80,90,91,99].

Chatbots have been identified to have a significant role in the healthcare system, specifically in remote triaging and health-related administrative routine work [56,58,61,64-66,70,71,82,92,94,95,99,100,103,104]. In studies that focus on remote triaging, 28% of the

included studies, chatbots were found to have the potential to relieve the burden on the healthcare system and primary care settings. By screening and assessing risks, chatbots can reduce unnecessary visits and provide referral suggestions.

Additionally, chatbots have been found to have a positive impact on healthcare administration tasks such as collecting and storing patient data. They help relieve workload, improve the efficiency of healthcare professionals, reduce the use of physical space, and minimize costs. Furthermore, the use of chatbots in remote triaging allows physicians to gain insights into patients' conditions and medical histories, enabling them to ask targeted questions and ultimately, streamline their workflow, saving time and resources.

Data from patient chatbots can also be visualized and analyzed, providing clues about patient experience and health outcomes, and capturing public health situations, as reported in one study conducted during the COVID-19 pandemic. This also helps offer patient-centered care by providing personalized content and tailored messages to patients' data and health records, as reported in 52% of all included studies. Thus, enhancing shared decision-making with the patients could be achieved, specifically with included studies reporting chatbots allowing communication between patients and healthcare professionals, and others promoting self-management towards patient-centered care by engaging them in their management plan to improve their retention in care, treatment adherence, and ultimately, health and quality of life outcomes [127], relieving some of those primary care burdens.

The utilization of artificial intelligence in chatbots: a promising but still evolving field

Our results showed that 56% of the included studies used AI-based chatbots while 22% were non-AI, leaving 22% without specifying either. According to the AI view, healthcare has long been seen as a promising area [128]. AI-based technologies represent a promising technique to improve future health outcomes and quality of life for many people worldwide [128]. In light of the advances in machine learning and artificial intelligence generally, expanding the scope of chatbots is expected to cause a mutation in their role in the healthcare system to assist clinicians [129,130] or even replace some of their duties. Considering the synergistic relationship between big data and artificial intelligence and the increasing availability of data in healthcare [131], AI-based chatbots with a health focus could make the best use of the vast, scattered healthcare data. This agrees with

one of the included studies [66], which discussed making the best use of the collected data as one of the benefits of chatbots.

Embodied chatbots: an appealing form of chatbot technology with potential benefits

Our results showed that seventeen studies (34%) indicated using embodied chatbots, justifying using avatars as engaging, an empathic tool to simulate social behaviors by using behavior and non-behavior actions such as voice, hand gestures, gaze cues, and other movements. Thirteen studies representing animated healthcare professionals seemed to be appealing to patients, as discussed by the included studies, and potentially established trust and therapeutic alliance between healthcare professionals and patients. On the other hand, four studies [89,94,101,102] representing virtual patients discussed improving the communication skills of medical students and healthcare professionals in medical education and offering complicated clinical scenarios in medical education, aiming to enhance the quality of healthcare.

Chatbots: a promising technology with potential benefits, but still facing challenges

Although this study focuses on the roles, users and benefits of chatbots, it is worth mentioning that despite the wide range of roles and benefits and the increasing number of health chatbots, they still face different challenges that need to be addressed, including ethical, technical, medico-legal and user-related experience [4,5,134-147].

Given the chatbots' strengths in this paper and weaknesses in the past literature, they seem a promising solution for many healthcare challenges; nevertheless, further research is needed to address their limitations and ensure their impacts for better integration into clinical practice towards efficient, safe, and equal health service provision.

This review has limitations. Rapid and systematic reviews have been shown to provide similar conclusions [132,133]. However, rapid reviews have their limitations, including in this work: a noncomprehensive restricted search to only two databases and inclusion criteria limited by date, language, and study design. Therefore, we may have missed some relevant studies. Other limitations were having one person (ML) perform most record/full-text screening and analyses, not conducting a quality appraisal given the review's descriptive focus, and presenting results only as a narrative summary [50].

2.5 Conclusions

This review provides a summary of chatbot roles and benefits in healthcare, as well as their users. The wide range of functions and effects of health chatbots indicate their significance as a key enabler for more efficient, quality care. Chatbots represent a time and cost-saving digital health tool that can fit various health populations, healthcare professionals, and healthcare organizational structures, shaping the future of healthcare with the different telehealth services they can provide. Chatbots offer a promising solution to empower patients and give them greater control over their health management for further development of healthcare. However, further research is needed to address their limitations.

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Transitioning from Chapter 2 to Chapter 3

Our results indicate that chatbots serve a wide range of populations from various groups in terms of age, sex, ethnicity, and socioeconomic and educational status due to their promising acceptability and usability. However, the digital divide [418,419,420], ethical issues in algorithms [421], the potential misuse of chatbots to completely replace established health services [422], as well as the social, economic, and political factors shaping users' experience [423] and contributing to the complexity of healthcare [418] could lead to adverse results of widening the gap between health populations, exacerbating inequalities in healthcare rather than minimizing them.

As the demand for innovative technologies in healthcare continues to rise, chatbots have emerged as invaluable tools in improving patient care and enhancing healthcare professionals' efficiency. These intelligent conversational agents play diverse roles, catering to a wide range of users and offering numerous benefits. In this context, the development and implementation of an existing chatbot named MARVIN have proven to be transformative in the field of healthcare. Building upon this success, a new version of MARVIN, called MARVIN-Pharma, has been specifically tailored to meet the needs and preferences of pharmacists working in HIV care. By providing comprehensive information on HIV and ART medications, MARVIN-Pharma aims to empower pharmacists to deliver accurate and up-to-date knowledge while attending to PWH.

To this end, I shift the focus Chapter 3 to a novel chatbot named MARVIN-Pharma, designed specifically for pharmacists attending to PWH. This new venture explores the integration of advanced conversational AI technology with the expertise of pharmacists, aiming to enhance their ability to retrieve HIV- and ART-related information efficiently, address patient queries, and ultimately contribute to better healthcare outcomes in the context of HIV care. Through this exploration, I aim to uncover the intricate workings of MARVIN-Pharma and elucidate its potential benefits for both pharmacists and PWH.

Therefore, the following chapter employs a comprehensive approach to tailor MARVIN-Pharma for pharmacists attending to PWH. This involves using a pharmacist needs assessment questionnaire based on the KAP model and TAM framework. The questionnaire serves to illuminate pharmacists' specific requirements and challenges in their interactions with PWH, bringing clarity to the chatbot's practical configuration and development to meet the pharmacist needs. The chapter explores the fusion of AI technology and pharmaceutical expertise,

highlighting its positive impact on HIV care and healthcare outcomes, by meeting pharmacist needs. The subsequent sections will delve into the questionnaire results and implications, building on this foundation.

Chapter 3 (Manuscript 2):

Informing the Development of a Chatbot to Respond to Pharmacist Needs in HIV Care: Preliminary Results from a Knowledge-Attitudes-Practices Questionnaire

Abstract

Introduction: Pharmacists need to retrieve up-to-date HIV- and antiretroviral therapy (ART)-related information when counseling people with HIV (PWH). MARVIN is an artificial intelligence-based chatbot initially developed to assist PWH in taking ART. We aim to adapt MARVIN for pharmacists attending to PWH in Québec, Canada. We need to generate evidence to inform its configuration and implementation. We aim to assess pharmacists' knowledge, attitudes, and practices in HIV care, and perceived acceptability, compatibility and self-efficacy regarding a version of MARVIN (MARVIN-Pharma) adapted to their needs.

Methods: An online cross-sectional Knowledge-Attitudes-Practices questionnaire was developed by selecting and modifying content from previously utilized questionnaires and administered to pharmacists in Québec, from December 2022 to May 2023. Variables included pharmacists' 1) knowledge about HIV, 2) involvement in HIV care, 3) barriers to HIV care, 4) attitudes towards providing care to PWH; and, regarding the chatbot in development, 5) perceived acceptability, 6) compatibility, and 7) self-efficacy. Data analysis was conducted using descriptive statistics and Rstudio software.

Results: 28 pharmacists participated (20 community and 8 hospital-based pharmacists). Pharmacists reported moderate knowledge of HIV, with a similar level of objective knowledge (47% correct response rate). They displayed positive attitudes towards various HIV care issues and moderate involvement in HIV care, with adherence counseling being the most frequently provided service. Lack of time, clinical tools, staff resources, and information or training in HIV were identified as significant barriers to providing HIV care. The proposed MARVIN-Pharma chatbot was generally perceived as acceptable and compatible with pharmacists' work, although a notable number remained undecided. All pharmacists agreed that they found it easy to use Internet health services, the driving force behind the development of MARVIN-Pharma.

Recommendations for MARVIN-Pharma entail the development of targeted educational materials and topic-specific information to bridge knowledge gaps, integration of patient information needs,

minimization of stigmatization, facilitation of HIV care services through reminders and guidelines, design of user-friendly interfaces with user feedback integration to improve usability, and establishment of a reliable and constantly updated evidence-based information resource linkage for MARVIN-Pharma.

Conclusion: Findings provide insights and recommendations for configuring and developing MARVIN-Pharma as a practical and innovative tool to meet the needs of pharmacists in HIV care.

3.1 Introduction

In today's healthcare, managing HIV requires interprofessional efforts, and pharmacists play a significant role in the care of people with HIV (PWH) [27-29]. As the healthcare professionals most accessible to the public, pharmacists often serve as the first and most regular point of contact for patients seeking medical treatment and advice [30-33], especially in community pharmacies, which offer access to medications and health-related advice [34]. Therefore, pharmacists play an essential role in supporting PWH by providing crucial assistance in the regular refill and management of their antiretroviral therapy (ART).

Problem: Pharmacists in Canada face challenges in staying up to date on recent advances in HIV treatments due to the wide range of available drugs and the limited time and increased workload as a result of their expanded patient care roles [39]. Limited exposure to HIV counseling, due to the relatively low number of PWH they encounter in their practice, further contributes to a deficiency in specialized knowledge and expertise in HIV-related treatments. Given the expanding patient care responsibilities shouldered by pharmacists, access to readily available and reliable information is crucial for pharmacists to navigate HIV treatment options and address the inquiries and concerns of PWH, in a manner that is comprehensible and tailored to their needs.

Proposed solution: Chatbots have emerged as a promising solution for facilitating the retrieval of medical information, particularly in the context of HIV and ART [40,41]. These chatbots, known as "conversational agents," are computer programs designed to mimic human conversation through various platforms, including websites, texting apps, and computer software [42-53]. The provision of validated HIV information to pharmacists could be effectively facilitated through the utilization of chatbots, which could serve as a valuable tool specifically tailored for HIV care within the field of pharmacy [54]. The use of artificial intelligence (AI) in healthcare has led to the creation of chatbots that can instantly answer users' questions in a user-friendly and easily accessible manner, regardless of their age or literacy level. Initial research findings derived from healthcare providers

have indicated that prospective users of chatbots express a significant need for information regarding medications, including their interactions with other drugs and dietary supplements [54,63]. Therefore, chatbots could provide an innovative solution for pharmacists in the healthcare industry, allowing them to access essential information and counsel PWH in a cost-effective and efficient manner, ultimately leading to improved quality of care. Hence, our overarching goal is to develop a unique AI-based chatbot and connect it with a constantly updated and verified source of information to help pharmacists serve their HIV patients. To do so, their precise needs in this regard require assessment.

Opportunity to Fill the Knowledge Gap: As far as we know, chatbots in healthcare have yet to be based on a targeted assessment of user needs, and little guidance is available to design chatbots for healthcare providers. During the Covid-19 pandemic in 2020, a team of experts, including physicians, pharmacists, PWH, researchers, and engineers at the McGill University Health Centre, guided the development of an innovative AI chatbot called Minimal AntiretRoViral Interference (MARVIN). Running on Facebook Messenger, MARVIN was created as a retrieval-based independent component analysis (ICA) trained to chat with PWH on various aspects of self-management of HIV in both English and French. The existing literature reveals a significant knowledge gap in the field of chatbot utilization, specifically for pharmacists involved in HIV care. To the best of our knowledge, there are currently no known chatbots, based on a targeted needs assessment, developed for this purpose in any other setting. By acknowledging this gap, our study indirectly aims to address the lack of research and development of chatbot tools tailored specifically for pharmacists working in HIV care, thus contributing to the advancement of technology-driven support systems in this critical domain of healthcare by configuring our existing AI-based chatbot (MARVIN) for pharmacists involved in HIV care to create MARVIN-Pharma. It will be developed and trained to converse with pharmacists and instantly answer their HIV-related questions with verified information in simple English or French to assist them in providing fast and reliable information to PWH.

3.2 Objectives

- Based on a Knowledge-Attitudes-Practices questionnaire among Québec pharmacists attending to PWH: to explore, describe and quantify:
    - Their level of knowledge and preparedness to counsel PWH;

- Their attitudes and comfort level towards providing HIV care; and
- Their practice in HIV care by assessing:
  - Their level of involvement; and
  - The barriers facing them.

Further objectives include the assessment of whether or not MARVIN-Pharma is compatible with their work, as well as the assessment of their perceived self-efficacy to use it. A final objective is the identification of the needs and preferences of pharmacists in HIV care regarding the chatbot characteristics or functions and chatbot content or information.

MARVIN-Pharma is expected to be eventually implemented in pharmacies throughout Québec and Canada.

3.3 Methods

3.3.1 Study Design

A modified version of the Knowledge, Attitudes and Practices (KAP) questionnaire for assessing the needs of Québec pharmacists in HIV care was employed. Selection and modification of the questionnaire were guided by previous scholarly works that employed similar questionnaires [192,279-284] to investigate the knowledge, attitudes, and practices of pharmacists, in addition to incorporating the usability Technology Acceptance Model (TAM) framework to align with the objectives of this research.

3.3.2 Selection and Enrollment of Participants

Number of participants

We aimed to recruit 40 pharmacists registered in Québec working either part-time or full-time.

Sample Size Justification

Based on the number of licensed practicing pharmacists in Québec [285], our target population; the tolerable margin of error; our confidence level; and the response distribution, our minimum recommended sample size for the questionnaire was set to be approximately 40 participants as indicated in Table 5, using an online sample size calculator [486]. This sample size enabled a minimum precision of 15 percentage points or less (half-width of a 95% confidence interval) for estimated proportions within the study population.

Table 5. Sample size

Margin of error	15 %

Confidence level	95 %
Target population size	9,385
Response distribution	50 %
Recommended sample size	43 (≈40)

It is anticipated that the sample size utilized in this study will effectively encompass a diverse representation of the target population, specifically including pharmacists from various geographical regions within the province, as well as individuals from diverse backgrounds.

Eligibility Criteria

We recruited pharmacists currently registered and working part- or -full-time in Québec. The study aims to recruit all actively practicing registered pharmacists in Québec, without any exclusions, regardless of their specialized field, to inform the design of MARVIN-Pharma. This inclusive approach acknowledges that all pharmacists may encounter PWH in their practice.

Recruitment Strategy

While recruitment is ongoing throughout Québec, Canada; it is focused on pharmacists affiliated with the National HIV and Hepatitis Mentoring Program (Programme National de Mentorat sur le VIH et les Hépatites or PNMVH) and the Centre hospitalier de l'Université de Montréal (CHUM). The PNMVH agreed to send out invitations for the questionnaire through their mailing list of currently registered pharmacists working in Québec affiliated with this organization.

The study employs a two-fold recruitment approach utilizing convenience sampling [287-289] and snowballing techniques [289]. Initially, a convenience sampling method is employed, where the first 40 eligible pharmacists who complete an online questionnaire are selected as participants. Additionally, a snowballing technique is implemented, wherein recruited pharmacists are encouraged to refer other pharmacists to participate in the study [289]. This combination of convenience sampling and snowballing facilitates the expansion of the sample size. To streamline the sampling process, the questionnaire includes a prompt for participants to provide the email addresses of other possibly interested pharmacists for referral [290]. Referred pharmacists are contacted via email to provide them with further information about the study. The invitation includes the email address of a designated staff member who can offer an explanation of the project.

In addition, PNMVH was asked to advertise the questionnaires on multiple platforms to reach the maximum number of participants (PNMVH newsletters, member emails obtained through PNMVH, and postings on PNMVH social media accounts).

3.3.3 Data Collection and Analysis

3.3.3.1 Data Collection

3.3.3.1.1 Theoretical Framework of the Questionnaire

Utilized Model: Knowledge, Attitudes, and Practices (KAP) model to gain insights into pharmacists' behavior regarding HIV care and their relationship with an AI-based chatbot.

Objectives of the KAP Model:

1. Describe the current population's knowledge, attitudes, and practices regarding HIV care.
    - Assess and describe existing knowledge, attitudes, and behaviors related to HIV care.
    - Provide insights for researchers, policymakers, and practitioners into influencing factors.
2. Problem identification and intervention planning:
    - Identify gaps and areas of concern in knowledge, attitudes, and practices of the population.
    - Inform the design of targeted interventions to address identified issues effectively.
3. Design appropriate specific interventions:
    - Tailor interventions based on the population's needs, attitudes, and practices.
    - Understand factors moderating the relationship between knowledge, attitudes, and practices for impactful intervention planning.

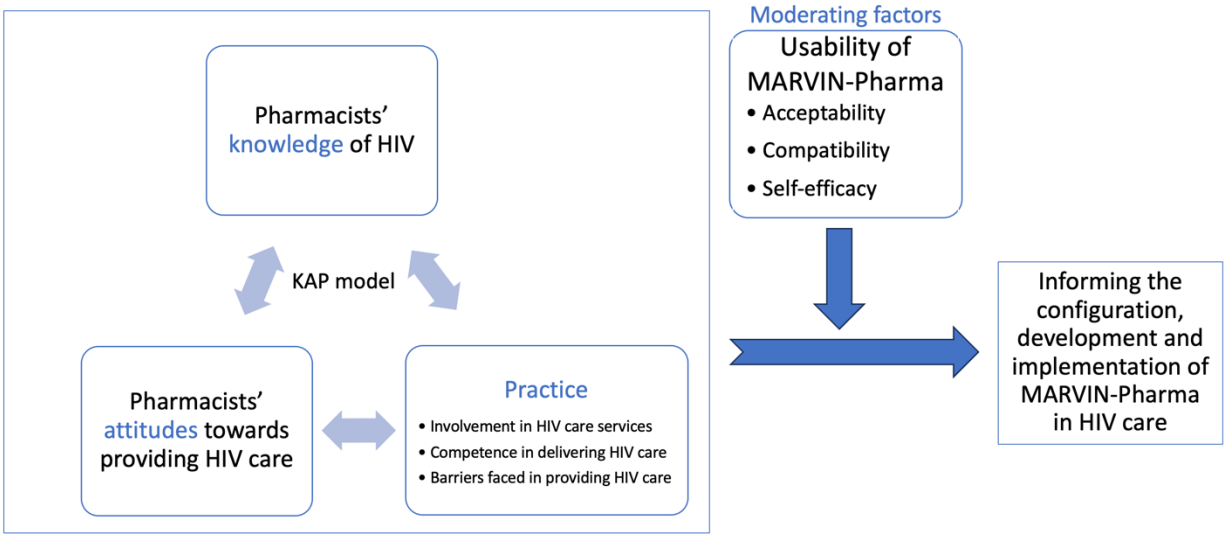
The main objective of using KAP model: Identify issues and develop effective interventions exploring how knowledge influences attitudes and practices in HIV care and AI-based chatbot utilization.

Evaluation Focus for MARVIN-Pharma:

- Assess pharmacists' current knowledge, attitudes, and practices (behavioral skills) in providing HIV care:
- Understand baseline knowledge and attitudes towards technology use in practice.
- Gain insights into current care provision for targeted improvements.
- Identify and evaluate moderating factors, including chatbot usability based on TAM subconstructs:
- Assess potential barriers and facilitators for successful integration of MARVIN-Pharma.
- Determine factors influencing pharmacists' acceptability and adoption of the chatbot.

- Utilize subconstructs from the Technology Acceptance Model (TAM) for a methodical approach to evaluating acceptability and usability, relevant within the present evaluation scope.

Figure 2. Questionnaire Framework



3.3.3.1.2 Questionnaire description

The questionnaire was developed by referencing and modifying content from previously utilized questionnaires for pharmacists in the past literature [192,279-284]. After these modifications, the questionnaire underwent pilot testing with a pharmacist, a physician, and a pharmacy student. Their feedback was analyzed, leading to further refinements to ensure enhanced reliability and validity. The utilized questionnaires were selected based on their relevance to the Knowledge-Attitudes-Practices (KAP) model, as well as MARVIN-Pharma use and subconstructs of the Technology Acceptance Model (TAM) usability framework, namely acceptability, compatibility, and self-efficacy of health technology. They were also chosen to measure pharmacists' engagement in HIV care, based on the KAP model, specifically to assess their knowledge, attitudes, practice competence and barriers to providing HIV care.

Details of questionnaire composition and description of its sections are included in the questionnaire guide in Appendix 2.

3.3.3.1.3 Technical procedures and questionnaire administration

Data presented in this thesis was collected from December 2022 to May 2023. Pharmacists were sent an invitation email and provided with the QR code for the questionnaire by the National HIV and Hepatitis Mentoring Program, including an explanation of MARVIN-Pharma and its potential. They were also offered a chance to ask questions by contacting a research team member by email

to ensure participants fully understood how MARVIN-Pharma may fit into their work. Pharmacists were also introduced to how MARVIN-Pharma could be used in their work to support their management of PWH.

Pharmacists completed the questionnaire online, and data were then recorded and stored in a secure online platform, REDCap© [291], which ensured ease of administration and data storage. Participants were compensated 50 CAD to fill out the questionnaire. The questionnaire accepted responses for approximately 5 months, from mid-December 2022 to May 2023. The questionnaire instrument was developed in English and then translated into French using the forward-backward translation method. The initial translation was conducted by a pharmacy student in the research team who is a native French speaker [292]. Subsequently, the translation was retranslated back into English to check for any discrepancies. To ensure linguistic and cultural appropriateness, the translated questionnaire underwent a rigorous pretesting process. Two members of the research team, specifically a physician and a pharmacy student, carefully reviewed the questionnaire for clarity, comprehensibility, and coherence. The pretesting phase aimed to enhance the quality of the questionnaire, facilitating unambiguous interpretation and ensuring its suitability for the intended population.

3.3.3.2 Statistical analysis

Descriptive statistics were used and visualized using stacked bar charts and tables to summarize the questionnaire's five sections: sociodemographics, knowledge, attitude, practice, and MARVIN-Pharma acceptability, compatibility, and self-efficacy.

Continuous variables (perceived knowledge, attitudes, involvement in HIV care services, competence in providing HIV care, barriers faced in delivering HIV care, and usability subconstructs, along with certain sociodemographic and professional characteristic data) were presented primarily as mode and median. Additionally, the mean ± standard deviation (SD) was utilized to provide further insights.

Categorical variables (sociodemographic and professional characteristics as well as objective knowledge) were presented as frequency and percentage.

A guide for the questionnaire analysis is included in Appendix 2.

Data analyses were conducted using Microsoft Excel and R statistical software [293].

3.3.4 Research Ethics Board (REB)

REB review exemption was obtained from the MUHC REB on September 8, 2022. The exemption from further REB review for the project was justified based on its specific objective to develop a healthcare provider-centered chatbot, taking into account the needs identified by its potential users, namely pharmacists. According to the definition of "research" outlined in Article 2.1 of the Tri-Council Policy Statement (TCPS2, 2018), the project did not fall under the purview of research activities. Consequently, the exemption was warranted, and no additional REB review was deemed necessary.

3.4 Results

Due to challenges in reaching the target number of participants and extended timelines for recruitment, we made the informed decision to conduct a preliminary analysis and provide early results during the ongoing recruitment phase. This approach was justified by several factors: early identification of trends and insights, informed decision-making to optimize recruitment, mitigation of recruitment challenges, efficient time management, demonstration of progress and dedication, facilitation of peer support and collaboration, enhanced credibility and transparency, identification of gaps and refined research questions, and early publication opportunities. Integrating preliminary results in the thesis strengthens the research's credibility and ensures a more user-centric and impactful chatbot development process.

We recruited 28 pharmacists in Québec, Canada, from December 2022 to May 2023, with ongoing efforts to reach our target sample size of 40 pharmacists.

3.4.1 Sociodemographic and Professional Characteristics

Table 6 presents a snapshot of the sociodemographic and professional characteristics of the pharmacist respondents. It shows that the majority of pharmacists work in Montreal and that respondents represent a diverse group in terms of age, ethnicity, sexual orientation, and gender. The average age of pharmacists is 35, and the majority identify as French Canadian. There is also a notable representation of various ethnic backgrounds, with a significant proportion of pharmacists identifying as East Asian, South Asian, and Arab or North African. In terms of sexual orientation, most pharmacists identify as heterosexual, while a smaller percentage identify as homosexual or bisexual. The gender distribution is nearly equal, with slightly more female pharmacists than male pharmacists.

In terms of professional characteristics, participating pharmacists have an average of 10 years of experience, indicating a mix of both seasoned professionals and those at the earlier stages of their careers. The majority of pharmacists in this study (20; 71%) work in community pharmacies; however, a significant proportion (8; 29%) work in hospital settings, highlighting the diverse practice settings for pharmacists. With regards to their patients, the surveyed pharmacists attended to patients from various groups. Most commonly, patients were women (50%), followed by individuals from the LGBTQ+ community (43%). Additionally, the pharmacists provided care for people who use injection drugs (32%), patients from countries where HIV is endemic (29%), geriatric populations (14%), and hemodialysis patients (4%). Pharmacists' patients were approximately 9% PWH, with an additional 12% at risk of acquiring HIV.

In the context of technology usage, on average, pharmacists have been using Facebook Messenger regularly for over 10 years, indicating familiarity with this communication platform. Moreover, pharmacists utilize an average of 2 health/work-related applications on their mobile devices, indicating their adoption of technology tools to support their professional practice.

Table 6. Sociodemographic and professional characteristics

Variable	Frequency / distribution N (%) / mean ± SD (range)
Geographic location of pharmacists' workplace:	
Montreal	17 (61%)
Other cities	11 (39%)
Age	35 ± 8 (23 – 52)
Ethnic groups of pharmacists:	
French Canadian	15 (54%)
Others	13 (46%)
Sexual orientation of pharmacists:	
Heterosexual	24 (86%)
Homosexual	2 (7%)
Bisexual	2 (7%)
Gender of pharmacists:	
Female	16 (57%)

Male	12 (43%)
Years of experience as a pharmacist	10 ± 8 (1 – 30)
Main setting of pharmacy practice:	
Community	20 (71%)
Hospital	8 (29%)
Groups of patients seen by pharmacists:	
People from LGBTQ+ community	12 (43%)
People from countries where HIV is endemic	8 (29%)
People who use injection drugs	9 (32%)
Women	14 (50%)
HIV-negative partners of PWH	5 (18%)
Others	8 (29%)
Percentage of patients with HIV	9 ± 15 % (0 – 75 %)
Percentage of patients at high risk of HIV	12 ± 16% (0 – 66 %)
Years of using Facebook Messenger regularly	10 ± 3 (1 – 18)
Frequency of using applications related to health/work on pharmacists' mobile devices	2 ± 1 (0 – 4)

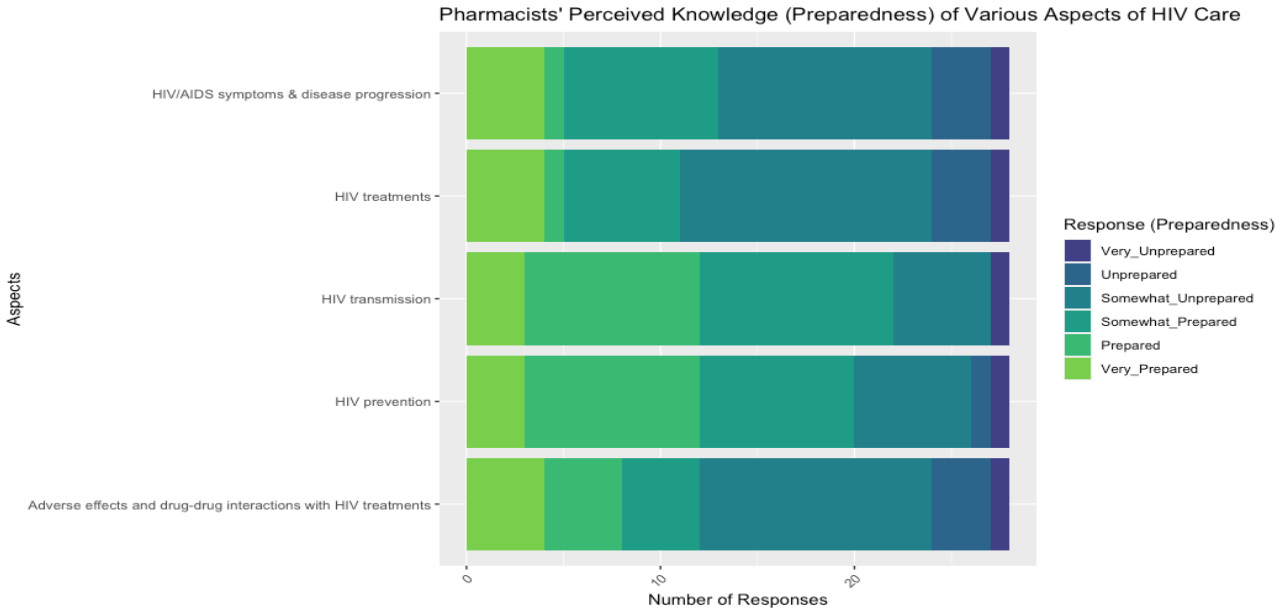
3.4.2 Knowledge

3.4.2.1 Perceived knowledge (preparedness)

This subsection includes the responses of pharmacists about their perceived knowledge of adverse HIV drug effects and interactions, HIV prevention, HIV symptoms and disease progression, HIV transmission, and HIV treatment. Pharmacists reported moderate knowledge of different aspects of HIV. Pharmacists felt: (a) most prepared to advise their patients on HIV transmission and prevention; (b) less aware of adverse drug effects and interactions; and (c) least prepared regarding knowledge of HIV treatment and HIV symptoms and progression, respectively.

Figure 3 shows a stacked bar chart of the pharmacists' responses distribution assessing their perceived knowledge and their preparedness in counseling PWH about: adverse HIV drug effects and interactions, HIV prevention, HIV symptoms and disease progression, HIV transmission, and HIV treatments.

Figure 3. A stacked bar chart of the responses distribution of pharmacists' perceived knowledge (preparedness) in counseling PWH across various aspects of HIV



3.4.2.2 Objective knowledge

Pharmacists had a moderate level of objective knowledge consistent with their self-assessment. Varying percentages of correct answers were obtained for different questions. The total percentage for correct responses was 47%, while the total for incorrect responses was 53%.

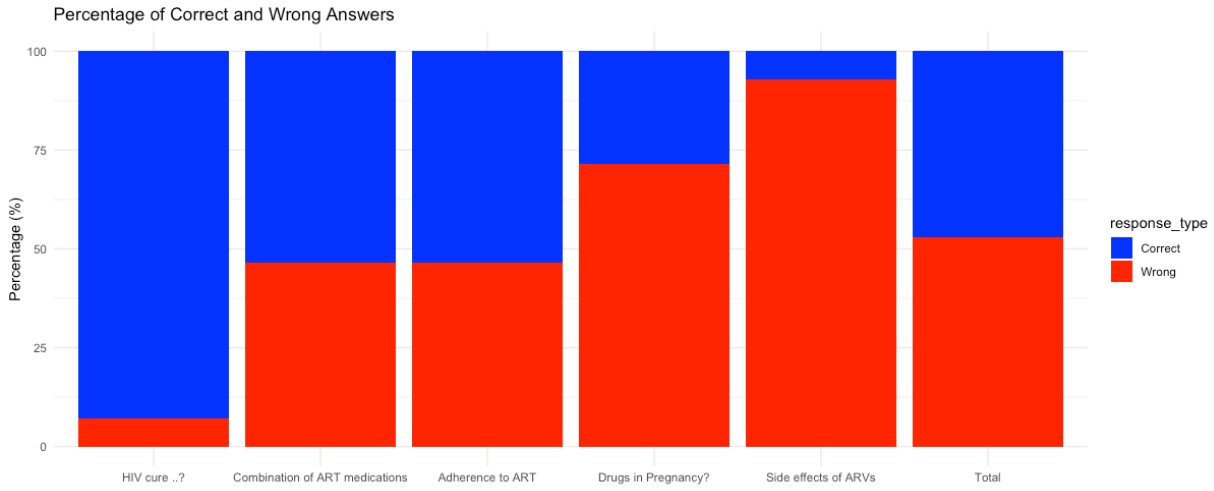
The results indicate that: (a) For Question 1 and Question 2: 54% of respondents answered these questions correctly, which suggests that some pharmacists may not have sufficient knowledge to advise PWH regarding their antiretroviral treatment regimen and have a limited understanding of the complexity of HIV treatment; (b) For Question 3: 93% of respondents correctly answered this question, indicating a an extremely high understanding of the current state of HIV treatment; (c) For Question 4: Only 7% of respondents correctly identified common side effects of Nevirapine, indicating a lack of knowledge about ART medications' side effects; and (d) For Question 5: 29% of respondents correctly identified a drug that is not recommended in pregnancy, indicating some knowledge of HIV treatment during pregnancy.

The findings show that, out of the 28 pharmacists who answered all 5 questions, 6 only correctly answered one question (20%); 9 correctly answered 2 questions (40%); 10 correctly answered 3 questions (60%); 3 correctly answered 4 questions (80%); and no participant achieved a perfect

score by answering all questions correctly, nor did any participant fail to answer all questions correctly.

Figure 4 shows a stacked bar chart of the percentage of pharmacists' correct and incorrect responses to each of the five questions on HIV cure, combinations of ART medications, adherence to ART, drugs in pregnancy, and side effects of antiretrovirals.

Figure 4. A stacked bar chart of the pharmacists' objective knowledge (percentage of the correct and incorrect answers of pharmacists' responses to each of the five questions)



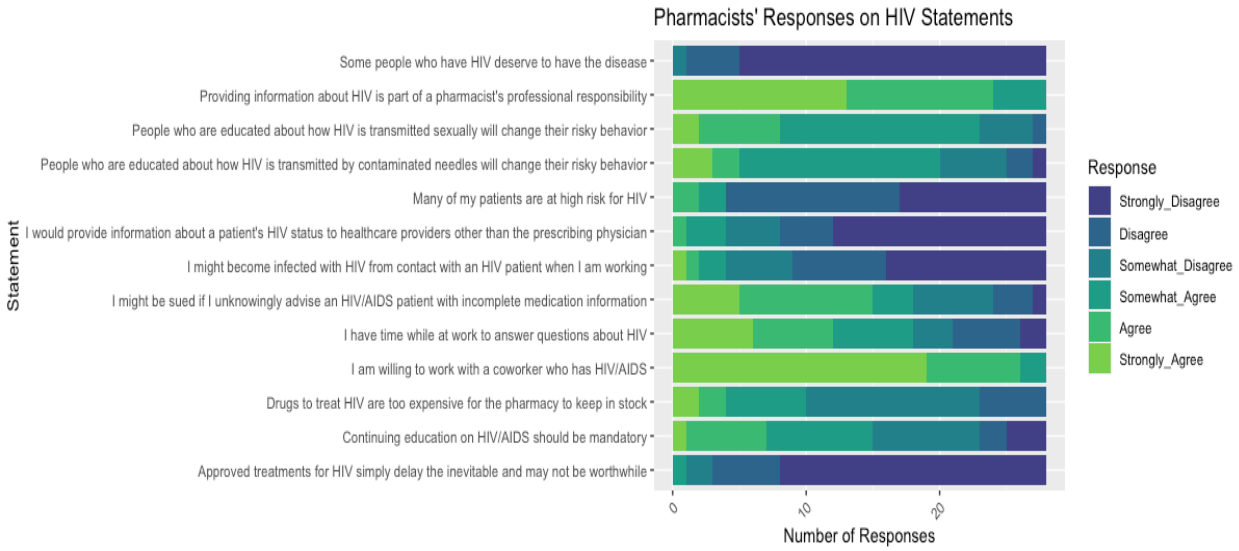
Questions and answers are included in Appendix 3.

3.4.3 Attitudes

The results show that, for the most part, pharmacists indicated a positive attitude toward various HIV issues in providing HIV care.

This section shows that all pharmacists surveyed (100%) agreed that providing information about HIV is part of their professional responsibility and 64% agreed that they have time while at work to answer questions about HIV. There was a mixed response to the belief that educating people about how HIV is transmitted will change their risky behavior, with a higher level of agreement for sexual transmission (82%) than through contaminated needles (71%). All pharmacists (100%) disagreed with the statement that some PWH deserve to have the disease and 96% also disagreed that approved treatments for HIV are not worthwhile. There was some concern among pharmacists about potential legal issues related to advising PWH with incomplete medication information. Still, they generally felt confident about their ability to work with coworkers who have HIV. Finally, 54% of pharmacists supported mandatory continuing education on HIV among pharmacists.

Figure 5. A stacked bar chart of the pharmacists' attitudes toward each statement of issues in providing HIV care



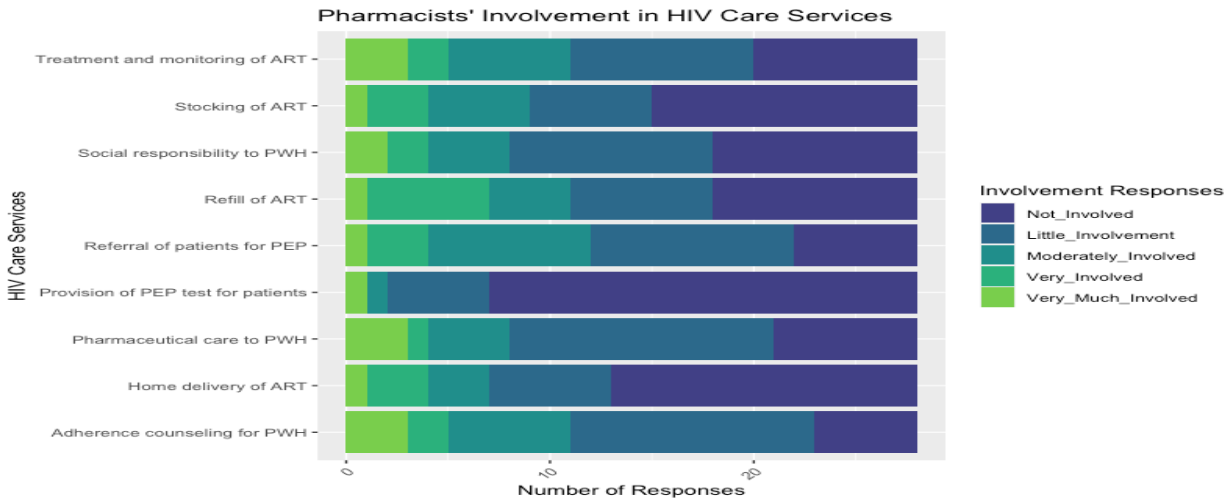
3.4.4 Practice

3.4.4.1 <u>Involvement</u>

Adherence counseling for PWH, followed by referral of patients for postexposure prophylaxis and treatment and monitoring of ART, were the most provided services by pharmacists, respectively. Pharmacists had mixed levels of involvement and varying ratings for different services. Overall, they had moderate involvement in HIV care services.

Figure 5 shows a stacked bar chart of the pharmacists' responses to their involvement in different HIV care services including pharmaceutical care, adherence counseling, referral for postexposure prophylaxis, refill of ART, stocking of ART, social responsibility, treatment and monitoring of ART, provision of postexposure prophylaxis test and home delivery of ART.

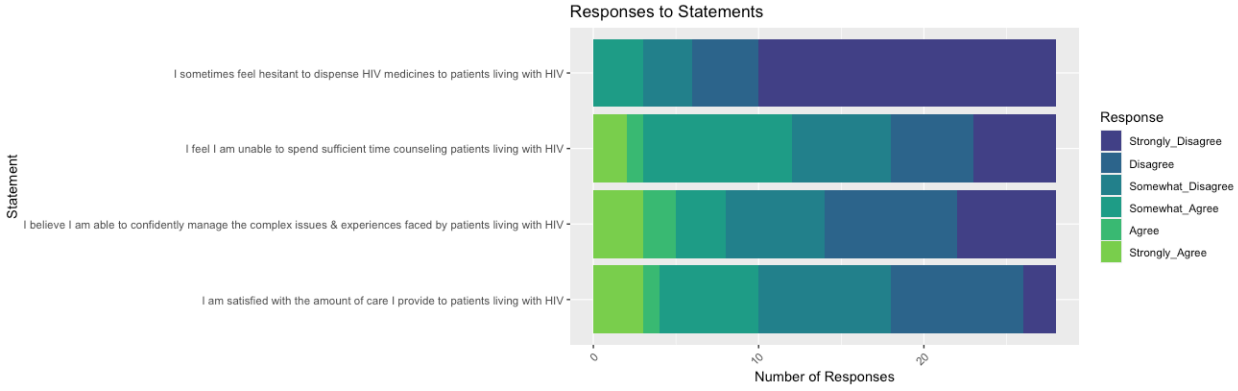
Figure 5. A stacked bar chart of the pharmacists' responses to involvement in HIV care services



3.4.4.2 Competence

Pharmacists reported varying levels of confidence, satisfaction, and ability to spend time counseling PWH, with a moderate level of satisfaction with the care provided.

Figure 6. A stacked bar chart of pharmacists' responses to statements about competence in providing HIV care



3.4.4.3 Barriers

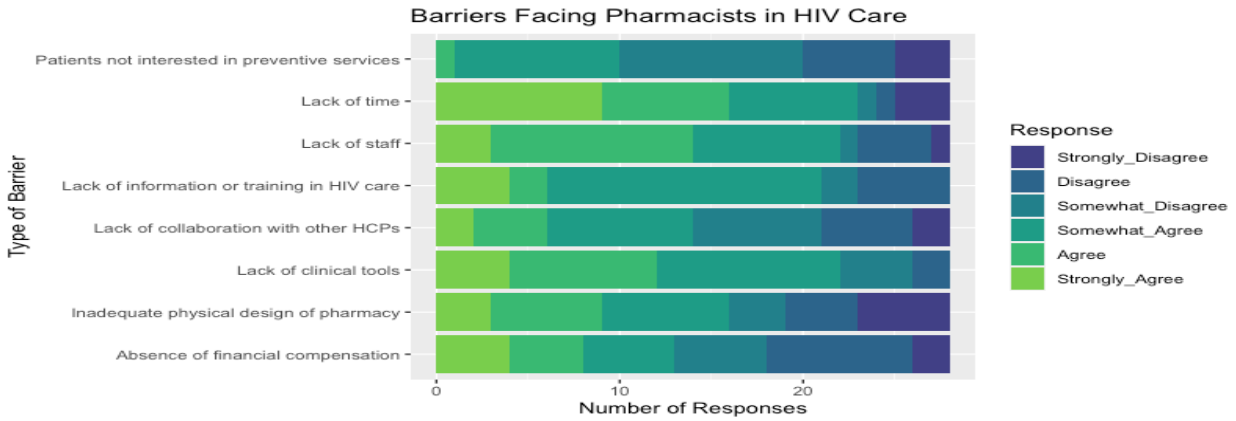
This subsection highlights that the highest-rated barriers to providing HIV care included a lack of time, clinical tools, staff resources, and information or training in HIV, respectively.

On the other hand, the barriers with the lowest rates were related to patients' lack of interest in preventive services and the absence of financial compensation, respectively.

Figure 6 shows a stacked bar chart of pharmacists' responses assessing the barriers facing them in HIV care, including lack of clinical tools, collaboration with healthcare providers, information or

training in HIV, staff, financial compensation, space or physical design, time, and patient interest in preventive services.

Figure 6. A stacked bar chart of barriers facing pharmacists in providing HIV care



3.4.5 Usability:

3.4.5.1 <u>Acceptability</u>

Proposed MARVIN-Pharma chatbot was perceived as acceptable by pharmacists, with a considerable number remaining undecided.

3.4.5.2 <u>Compatibility</u>

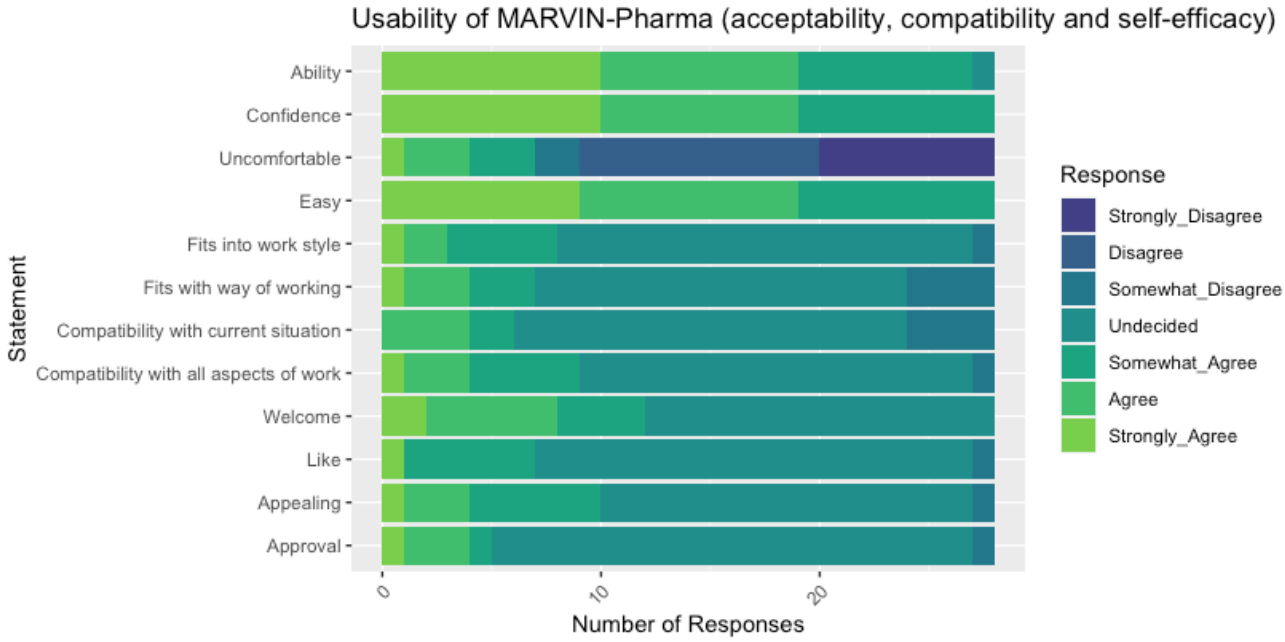
Pharmacists perceived the proposed MARVIN-Pharma as compatible with their work, albeit to varying degrees, with a notable number remaining undecided.

3.4.5.3 <u>Self-efficacy</u>

All pharmacists (n=28; 100%) agreed that it is easy for them to use Internet health services. While only 7 pharmacists (25%) reported feeling uncomfortable using Internet health services, most (n=21; 75%) felt comfortable, and all of them expressed confidence in their abilities to use these services. Moreover, the majority (n=27; 96%) believed that they could use Internet health services with little effort, while only one pharmacist (4%) remained undecided.

Accordingly, the usability subconstructs suggest that pharmacists generally found the idea of MARVIN-Pharma acceptable and compatible with their work, and most indicated self-efficacy in using Internet health services, which could enhance their engagement and utilization of MARVIN-Pharma while attending to PWH.

Figure 7. A stacked bar chart of MARVIN-Pharma usability subconstructs (acceptability, compatibility and self-efficacy)



3.5 Discussion

The study had multiple objectives. First, it aimed to assess pharmacists' knowledge, attitudes, and practice in providing HIV care services. Secondly, it aimed to evaluate the acceptability and compatibility of the MARVIN-Pharma chatbot with their work. Additionally, it aimed to determine pharmacists' self-efficacy in using Internet health services, which served as the driving force behind the development of MARVIN-Pharma.

The findings of this study, aligned with those from a rapid review study on the roles, users, and benefits of chatbots in healthcare (included in Chapter 2), were intended to inform the configuration and adaptation of MARVIN-Pharma based on pharmacists' needs. This involved addressing gaps in their knowledge about HIV, competence, involvement, and barriers faced in HIV care. Furthermore, the study aimed to provide insight into the implementation of the chatbot by assessing pharmacists' attitudes towards delivering HIV care and the usability of MARVIN-Pharma.

Characteristics of Pharmacists and their Patient Population: Distribution and Diversity

Our findings highlight the diversity of pharmacists in terms of their geographic distribution, demographics, patient populations served, and technology usage. Such insights are crucial for

understanding the pharmacist workforce, designing targeted interventions, and enhancing the quality of care provided to various patient groups.

Pharmacists' Knowledge and Preparedness in HIV Care: Gaps to Fulfill by MARVIN-Pharma Chatbot

Our results showed that pharmacists perceived their knowledge of HIV to be moderate. Consistent with previous literature [279,294], our findings indicate that pharmacists felt most confident when advising patients about HIV transmission and prevention, topics which are frequently discussed in the lay press [294]. However, they felt least confident in (a) their knowledge of HIV treatment [294,279,295], and (b) symptoms and progression of HIV and adverse drug effects and interactions with HIV treatment, respectively. Similarly, the objective knowledge assessment showed a moderate level of knowledge, with only 48% of answers being correct. The proportion of respondents who accurately recognized the typical adverse effects associated with Nevirapine was found to be a mere 7%. This outcome may be expected, considering that Nevirapine is no longer included in the established guidelines for HIV treatment. Nevertheless, the analysis revealed no notable distinction in the responses between pharmacists with 15 or more years of experience and those with less experience, indicating an overall deficiency in understanding pertaining to the side effects of antiretroviral therapy medications. The relatively moderate HIV knowledge level of pharmacists in this study is consistent with other studies describing the knowledge of other health professionals with non-specialized knowledge of HIV [296,297]. While most pharmacists answered some questions correctly, others showed a lack of understanding, indicating deficits in knowledge about specific aspects of HIV care, consistent with previous studies [279,294,295,298,299,300,301]. The identified knowledge gaps concern the side effects of ART medications, HIV drugs to use in pregnancy, and counseling PWH regarding ART medication and ideal treatment regimens.

In addition to pharmacists' needs with regards to information, understanding the information needs of PWH can provide valuable insights for developing an effective chatbot for HIV care. Past literature focusing on PWH’s needs highlighted five categories of questions essential to them, including questions on diagnosis and prognosis, therapeutic medication, depressive symptoms, sexual relationships, and family and social life. Healthcare providers could use those patient interests to encourage active participation of PWH in the healthcare process [302]. Addressing pharmacists' knowledge gaps is crucial given that pharmacists' interventions, including counseling

PWH, can have a positive impact on PWH's knowledge of both the disease and ART use and storage, which may help improve PWH's compliance with ART regimens and reduce transmission rates of HIV [303]. Therefore, we recommend that MARVIN-Pharma begin by addressing the identified priority knowledge gaps in pharmacists' knowledge of HIV and PWH's information needs as one of the primary roles of health chatbots, as indicated in Chapter 2.

Pharmacists' Positive Non-Stigmatizing Attitudes towards Providing HIV Care Services

Our study also assessed pharmacists' attitudes towards providing HIV care services. It revealed that pharmacists hold favorable non-stigmatizing attitudes to providing HIV services, consistent with previous studies [280,294,298,300], and are willing to enhance their knowledge in this area to improve the provided services. In addition, our results indicated that most pharmacists believe that providing information about HIV is part of their professional responsibility. They also disagree with the statement that some people deserve to have HIV and that approved treatments are not worthwhile. However, there was a mixed response to the belief that educating people about how HIV is transmitted will change their risky behavior. These results indicate competent attitudes towards providing HIV care. Past literature found that healthcare personnel who had more work experience, especially related to PWH care, were less likely to have stigmatizing attitudes towards PWH [304]; however, younger pharmacists were more open to mandating continuing education on HIV. As one of the roles of chatbots (see Chapter 2) is providing educational material and training to HCPs, MARVIN-Pharma could assist in providing continuous education and training to pharmacists in the HIV domain. This could potentially improve pharmacists' confidence and clinical knowledge in HIV care, which is important to enhance their attitudes towards PWH, and thus PWH's health outcomes [279].

Pharmacists' Provision of HIV Care Services: Findings and Implications

Pharmacists can play an important role in the provision of HIV care services. Past literature has shown that pharmacy-delivered HIV services may be feasible to implement and acceptable to clients and providers. It also suggests pharmacy-delivered HIV services can reach those in need who may not otherwise engage in traditional clinic-based services [305]. In addition, work system and process designs for community pharmacy-medical clinic partnerships have also been studied to improve retention in care, antiretroviral adherence, and viral suppression in PWH [306]. Our study assessed the extent to which pharmacists provide various HIV care services. Although some pharmacists have been offering HIV services as part of their extended role as previously outlined

[29,36,37,129], their involvement has been low to moderate, as revealed through our study. Our results showed that their involvement was highest for adherence counseling and referral of patients for PEP, while it was lowest for the provision of PEP tests for patients and home delivery of ART. Moreover, pharmacists in this study agreed that HIV services should be part of pharmacy responsibilities. They were willing to offer HIV care services in their pharmacies, consistent with previous studies [280,307]. Although the overall involvement in HIV care services was higher in community pharmacists than in hospital-based pharmacists, pharmaceutical care and adherence counseling services were higher in hospital-based pharmacists, which could reflect greater clinical involvement of these pharmacists with PWH admitted to the hospital [294].

Based on the roles and benefits, and the users chatbots could serve in healthcare in Chapter 2, MARVIN-Pharma can help improve pharmacists' involvement in providing various HIV care services. For instance, MARVIN-Pharma can provide pharmacists with reminders, checklists or guidelines on specific tasks, such as providing PEP tests for patients and counseling them on their ART.

Barriers to Integrating HIV Services into Pharmacy Practice: Challenges and Potential Solutions

Consistent with previous studies [280,308,309], our results showed that the barriers most often faced by pharmacists included a lack of time, clinical tools, and staff resources, which can limit their ability to provide comprehensive HIV care services [305]. This highlights the need to address these barriers to improve the quality of HIV care services. Another significant barrier was a lack of information or training in HIV, which can lead to inadequate counseling and provision of care for PWH [156]. This underscores the importance of providing ongoing adequate education and training or even resources for information on ART and HIV care and management for pharmacists to improve their knowledge and skills and assist them in delivering quality HIV care.

As stated in Chapter 2, chatbots provide an innovative, practical solution for barriers related to pharmacists' time constraints, staff shortage and lack of information. For instance, MARVIN-Pharma can provide timely information and reminders on HIV care services to pharmacists, especially when staff resources are limited.

On the other hand, the identified lesser barriers were related to a lack of collaboration with other healthcare professionals, the inadequate physical design of the pharmacy space, patients' lack of interest in preventive services, and the absence of financial compensation for HIV service provision. Collaboration with other healthcare professionals, such as physicians and nurses, is

essential to provide comprehensive HIV care services, but it can be challenging due to communication barriers and lack of coordination [310]. These findings highlight the need for improved collaboration and communication between healthcare providers. Based on a previous study [306], the inadequate physical design of the pharmacy space can also be a barrier to the integration of HIV services into pharmacy practice, as it can limit the privacy and confidentiality for PWH, emphasizing the need for optimizing the pharmacy environment for HIV care delivery. Another study [311] showed that patients' lack of interest in preventive services and the absence of financial compensation can also function as barriers to the integration of HIV services into pharmacy practice. Thus, the absence of financial compensation still requires attention to the need for financial incentives for pharmacists attending to PWH. In addition, public awareness campaigns to encourage PWH to take a more proactive role in their healthcare is necessary to minimize the patients' lack of interest in preventive services.

All the proposed solutions to overcome the barriers faced by pharmacists can help improve the quality of care and health outcomes for PWH and increase the involvement of pharmacists in the provision of HIV services.

Pharmacists' Familiarity with Digital Tools and Usability of MARVIN-Pharma for Improving HIV Care Services

Pharmacist familiarity with digital tools and technology usability are key factors in ensuring the effectiveness of the MARVIN-Pharma chatbot for HIV pharmacy care. However, there is limited research on this topic. In our study, pharmacists reported frequent use of health/work-related applications on their mobile devices and a high number of years of using Facebook Messenger regularly, indicating familiarity and comfort with technology, social media, and instant messaging apps. In addition, our study assessed three usability sub-constructs for MARVIN-Pharma and found that pharmacists generally perceived the idea of MARVIN-Pharma as acceptable and compatible with their work. Most of them expressed self-efficacy and confidence in using Internet health services, which could enhance their engagement and utilization of the chatbot. These data are consistent with previous literature [205-213], indicating the acceptability and satisfaction of pharmacists toward using social media and digital health apps.

On the other hand, it is worth mentioning that most participants had neutral answers to the questions in this section, possibly due to the hypothetical nature of the questions. However, low or neutral usability ratings in pre-intervention usability testing are not necessarily a cause for

concern. Instead, they provide valuable feedback for intervention developers to improve usability, accessibility, and effectiveness.

MARVIN-Pharma Chatbot as a Practical Innovative Tool for Pharmacists in HIV care

Chatbots can be a practical innovative tool for pharmacists in HIV care as an ART- and HIV-related reliable and instant information retrieval tool. This is demonstrated by a study showcasing the successful implementation of an autonomous chatbot named SHIHbot on the Facebook platform [40]. SHIHbot answers a wide variety of sexual health questions on HIV/AIDS [40]. Another study explored the potential application of conversational agents in HIV testing uptake among high-risk populations [41]. Another proof-of-concept study of an artificial intelligence-based chatbot in a French hospital showed that the chatbot seems to be a relevant tool for hospital caregivers, helping them obtain the reliable and verified information they need regarding drugs and pharmacy organization [54]. Additionally, a scoping review explored the technical aspects and development methodologies associated with chatbots used in the medical field to explain the best methods of development and support chatbot development researchers on their future work [251]. Chatbots have also been implemented worldwide as a prompt response to the COVID-19 pandemic, providing reliable health information and preventing people from seeking assistance in healthcare centers and being unnecessarily exposed to the virus [312]. By presenting these different projects, the intention is to demonstrate the wide-ranging capabilities of chatbots and their potential to address various challenges in HIV care, support healthcare providers, improve patient outcomes, and enhance the delivery of quality healthcare services. Our needs-assessment study provides insights into pharmacists' knowledge, attitudes, and practices regarding providing HIV care services. Additionally, it underscores the potential of the MARVIN-Pharma chatbot to bridge the gaps identified in this study. It stresses the importance of providing pharmacists with ongoing information resources to enhance their knowledge and skills and enable them to deliver quality HIV care to PWH. Furthermore, the MARVIN-Pharma chatbot can offer a practical solution to the challenges faced by pharmacists in integrating HIV services into their daily practice. These results are consistent with the recommendations of a systematic review [207] that advocates for integrating innovative digital technologies to support pharmacists in their work, particularly in public health interventions such as counseling patients. This integration aims to address the needs of patients who may encounter a digital divide—a gap between those with access to digital technologies and the internet, and those without due to factors like socio-economic status,

geographic location, age, and education level. Another study [313] that focused on Canadian pharmacists revealed that while they were aware of the available online resources, most believed they needed to upgrade their computer skills. Given this potential issue and the user-friendliness of chatbots, as indicated in chapter 2, the MARVIN-Pharma chatbot is a promising and effective tool for pharmacists, especially those with limited computer skills.

Recommendations and Implications

The recommendations and implications presented in Appendix 4 for the development of MARVIN-Pharma are justified through a knowledge translation approach. This approach involves bridging the gap between research findings in the rapid review of the chatbots and the preliminary report of the pharmacist needs assessment and their practical application in real-world settings. By incorporating knowledge translation principles, the recommendations draw strength from evidence-based insights, ensuring that the development of MARVIN-Pharma is grounded in a thorough understanding of the roles and benefits of chatbots in healthcare and tailored to meet the specific needs of pharmacists in HIV care.

Limitations of the study

This study is limited by the sample's small size (n = 28 pharmacists), potential sampling bias, limited diversity, and limited generalizability. The sample may not be representative of the population of interest, leading to biased results. For example, Montreal is overrepresented as the most common geographic location of pharmacists' workplaces. In terms of experience, there is a wide range, but the average of 10 years suggests a relatively experienced group overall. The female gender is slightly overrepresented among pharmacists. However, multiple recruitment strategies were employed to reach pharmacists from different sociodemographic and professional characteristics. Furthermore, recruitment is still in progress, aiming to address such bias.

Secondly, the data of this study relies on a self-administered questionnaire, which may be prone to bias or subjectivity, such as response, recall, social desirability, and confirmation bias. Some respondents may have provided inaccurate or untruthful answers, or they may have misunderstood the questions. However, one strategy used to minimize bias was employing a combination of subjective and objective questions in the knowledge assessment section. Social desirability bias may have affected the quality of study results. Indeed, participants may have felt pressure to provide socially desirable answers, more specifically when answering questions related to attitudes.

This study is also characterized by a limited scope and depth. The questionnaire's design may restrict the study's scope, hindering exploration of additional relevant factors and limiting in-depth information gathering. Closed-ended questions may inadequately capture the nuances of the research question, potentially impeding a comprehensive understanding of pharmacists' perspectives and opinions. However, it is important to note that this project represents a partial component of a larger mixed methods study, which encompasses qualitative data collection. This qualitative data, which will specifically address the opinions and perspectives of pharmacists regarding the integration of MARVIN-Pharma into their daily work routine, will be published separately as part of the broader study, subsequent to the submission of this thesis.

In addition, the study is limited by its cross-sectional design. A cross-sectional questionnaire conducted only once does not allow for follow-up or further investigation to confirm or expand on the findings. It is not possible to determine the cause-and-effect relationship between the variables of interest or establish the study's reliability over time which refers to the consistency and stability of the study's findings or results over time or across different conditions.

Self-selection bias which arises from the possibility that participants choose to respond to the questionnaire differ from those who do not respond, leading to biased results. For example, those pharmacists who are more interested or knowledgeable about using chatbots in HIV care may be more likely to respond.

In relation to the reliability and validity issues of the questionnaire, the questionnaire was piloted by a healthcare provider and a pharmacy student in the research team to minimize this bias. In addition, the questionnaire was translated from English to French by a pharmacy student who is a native French speaker.

In terms of the confounding bias, this preliminary report does not include a specific presentation of such biases in the methods or results sections. However, acknowledging the potential influence of confounding variables – such as a pharmacist’s age, gender, and experience – on the overall findings, we plan to implement various statistical techniques to control for these factors. It is essential to note that the absence of detailed confounding analysis in this preliminary report is attributed to its provisional nature, which may not reveal statistically significant group stratification due to the limited sample size.

3.6 Conclusion

In this study, we assessed the needs of pharmacists to configure a chatbot for HIV pharmacy care. We present several considerations and recommendations for informing the design and development of MARVIN-Pharma for the potential use by pharmacists in their daily work routine while attending to PWH.

This study found that the pharmacists had a moderate level of knowledge about HIV, highlighting the knowledge gaps to address in MARVIN-pharma's content configuration and development. For instance, pharmacists seem to know little about ART side effects and pregnancy but, overall, are moderately knowledgeable on the issues assessed, indicating that there is still room for improvement, particularly through the proposed MARVIN-Pharma chatbot as an information retrieval tool. Furthermore, pharmacists showed positive attitudes towards providing HIV care and improving their knowledge about HIV. They also showed overall low to moderate involvement in delivering HIV care services, with higher involvement in specific areas, particularly in relation to adherence counseling to PWH. In addition, our study assessed barriers facing pharmacists in providing adequate HIV care services. The most prevalent included lack of time, clinical tools, staff resources, as well as information and training in HIV, which can limit the ability of pharmacists to provide comprehensive HIV care services. The HIV care barriers identified suggest MARVIN-Pharma could help pharmacists save time in the context of limited access to staff and information. Additionally, pharmacists showed a high rate of utilizing smart devices—intelligent electronic devices capable of various functions—comfort with using healthcare applications, and a high frequency of using Facebook Messenger, the driving portal for the chatbot. They also found the idea of MARVIN-Pharma acceptable and compatible for their work and reported self-efficacy to use Internet health services.

Therefore, the overall findings could be used to inform the development and configuration of MARVIN-Pharma to improve the quality of HIV care services provided by pharmacists. In addition, this study provides insight into a framework for future chatbots, portals, and other health applications adapted from one specialty to another and from pharmacists to other healthcare providers and patients.

Chapter 4: Overall Conclusion

The use of chatbots in healthcare is expanding and proving to be revolutionary for healthcare providers and patients alike. Health chatbots' wide range of functions and effects indicate their significance as a key enabler for more efficient, quality care. Chatbots represent a time- and cost-saving digital health tool that can serve various health populations, healthcare professionals, and healthcare organizational structures, thus shaping the future of healthcare. Chatbots are versatile tools that can help healthcare professionals to automate many routine tasks, freeing them up to focus on more complex patient care issues.

The first manuscript in this thesis was a rapid review to explore existing chatbots used in healthcare to define their roles, characteristics, users, and benefits as a means to inform the configuration, development, and implementation of MARVIN-Pharma for pharmacists in HIV care.

Table 7. Summary of results (The rapid review)

Roles	**Users**	**Benefits**	**Characteristics**
Remote consultation and treatment advice	Chronic and/or older patients	Promotion of health equity	AI-based chatbots
Education and skills-building	Healthy adults and the general population	Improvement of healthcare quality	Non-AI chatbots
Health behavior promotion	Women	Promotion of patient-centered care	Instant messaging app-driven chatbots
Self-management and monitoring	Populations with mental health issues	Relief of administrative or clinical burdens	Embodied conversational agents • Virtual healthcare providers • Virtual patients for medical education
Remote triage	Children	Assessment of a public health situation	

Health-related administrative tasks	Healthcare professionals and students	Making the best use of the collected data	
Research purposes			

Table 8. Summary of results (The preliminary report)

Section		Results
Pharmacists' knowledge	Perceived knowledge (preparedness)	Pharmacists reported moderate knowledge of different aspects of HIV, feeling most prepared to advise on HIV transmission and prevention. They felt less aware of adverse drug effects and interactions and least prepared regarding knowledge of HIV treatment and symptoms. Range of scores was relatively wide. The overall average mean score was 4 (SD = 1).
	Objective knowledge	Pharmacists had a moderate level of objective knowledge consistent with their self-assessment. The total percentage for correct responses was 47.
Their attitudes		Pharmacists generally had positive attitudes toward providing HIV care.
Their practice	Involvement in HIV care	Adherence counseling for PWH, followed by referral of patients for postexposure prophylaxis and treatment and monitoring of ART were the most provided services, respectively. Overall, they had moderate involvement in HIV care services.
	Competence in delivering HIV care	Pharmacists reported varying levels of confidence, satisfaction, and ability to spend time counseling PWH. Moderate level of satisfaction with the care provided.
	Barriers facing them while proving HIV care	Lack of time, clinical tools, staff resources, and information or training in HIV were identified as significant barriers.

MARVIN-Pharma usability	Acceptability	Proposed MARVIN-Pharma chatbot was perceived as acceptable by pharmacists, with some remaining undecided.
	Compatibility	Pharmacists perceived the proposed MARVIN-Pharma as compatible with their work, with some remaining undecided.
	Self-efficacy	Pharmacists expressed confidence in their abilities to use Internet health services and believed they could use them with little effort.

With the expanding role of pharmacists in healthcare, including HIV care, pharmacists are involved in providing education to patients about medication-related care, assessing patients' willingness and ability to adhere to ART regimens, providing initial or follow-up counseling on HIV-related disease and ART medications, and evaluating adherence to therapeutic regimens.

The rapid pace of advancements in HIV care means that pharmacists must continuously seek current information to provide optimal patient care. Pharmacists are often valuable sources of drug information for patients and other healthcare providers. However, with a vast array of prescription and non-prescription drugs available in Canada and the large number of biomedical journal articles published each year, pharmacists experience tremendous difficulty staying abreast of recent advances, especially with their limited time and recent increases in workload as a result of their expanded patient care roles. Pharmacists need easily accessible, reliable information about HIV drugs and health to efficiently navigate the abundance of HIV-related treatment options and to answer questions of PWH in a manner that the latter can understand. Access to quality research resources and the ability to use them effectively is critical for pharmacists to provide accurate information to patients and other healthcare providers.

Assessing the needs of Québec pharmacists to inform the configuration of the MARVIN-Pharma chatbot for HIV care, pharmacists showed a moderate level of knowledge about HIV, positive attitudes towards providing HIV care, and some involvement in delivering HIV care services. These findings indicate that there is still room for improvement, particularly in different areas of knowledge about HIV in addition to pharmaceutical care, social responsibility related to their ethical obligation and duty to contribute positively to the well-being and support of PWH, and adherence counseling. Our results identify and highlight the need for additional information resources through MARVIN-Pharma to help pharmacists become more involved in providing comprehensive HIV care services and improve their knowledge and attitudes towards HIV care

and skills to assist them in delivering quality HIV care. Therefore, MARVIN-Pharma offers a practical solution for barriers facing pharmacists in providing HIV care, such as lack of knowledge of HIV and ART, competence in providing HIV care, and lack of time and staff.

Moreover, our findings suggest that implementing the chatbot in Québec pharmacies is feasible and meets the participants' perception of its usefulness and compatibility with their work. We also found a high rate of smart device use, comfort with using healthcare applications, and a high frequency of using Facebook Messenger, the driving portal for the chatbot.

Furthermore, this thesis introduces a framework for developing versatile digital health tools, such as chatbots and portals, that can be adapted and customized for different healthcare specialties and settings. The framework aims to overcome limitations of existing tools designed for specific specialties or user groups, promoting wider applicability among healthcare providers and patients. The findings can inform the development of chatbots, health apps, and portals for various health populations.

As a next step, I plan to utilize these results in my future Ph.D. studies in the Department of Family Medicine at McGill University. My goal is to contribute to the enhancement of the chatbot designed for PWH at the McGill University Health Centre, , focusing on shaping a targeted implementation strategy. This strategy aims to bolster medication adherence and enhance overall health outcomes for this specific patient population. By utilizing the insights gleaned from this thesis, I plan to integrate effective strategies and tailored features into the chatbot's design, aimed at optimizing treatment plan adherence and ultimately fostering improved health outcomes for PWH.

Expected Thesis Contributions

Contributions to academic and clinical practice

This thesis is expected to bring a significant and innovative contribution to the literature on the roles, users and benefits of chatbots in healthcare. By informing the configuration of MARVIN-Pharma, it will ensure that the chatbot's content and features are relevant and address the needs and preferences of pharmacists. Consequently, it should facilitate the successful integration, implementation, and sustainability of the chatbot in HIV care and pharmacists' work. It should have positive impacts on care quality and patients' adherence, as well as pharmacists' knowledge, attitude, practice, and, ultimately, pharmacist-patient relationships, trust, and communication.

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Appendices

Appendix 1. Questionnaire

Questionnaire in English

Please complete the survey below.

Thank you!

Contact Information	
First Name	_____
Last Name	_____
ZIP/postal code of your workplace	_____
Phone number	_____ (Include Area Code)
Email	_____
Age	_____ (Years)
Ethnic Group(s) or Family Background(s)	☐ Aboriginal or Indigenous ☐ English Canadian ☐ French Canadian ☐ French ☐ British ☐ Other Eastern/Western European ☐ East Asian ☐ South Asian ☐ West Asian ☐ Arab or North African ☐ Latin American ☐ African ☐ Black ☐ Caribbean ☐ Pacific ☐ Mixed race/ethnicity ☐ Other
If other, please specify:	_____
Sexual Orientation	◯ Heterosexual ◯ Bisexual ◯ Homosexual ◯ Asexual ◯ Other
If other, please specify:	_____

Gender	◯ Female ◯ Male ◯ Non-binary ◯ Other
If other, please specify:	_____
Years of experience as a pharmacist	_____ (Years)
Main type of pharmacy practice	◯ Community pharmacy ◯ Hospital pharmacy ◯ Other
If other, please specify:	_____
I identify as having specialized knowledge in HIV care	◯ Strongly Agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly Disagree
What proportion of your patient population is HIV-positive?	*(Place a mark on the scale above)*
What proportion of your patient population is not diagnosed with HIV but at high risk of HIV acquisition?	*(Place a mark on the scale above)*
Overall, which of the following groups does your practice significantly serve?	☐ First Nations ☐ People from LGBTQ+ communities ☐ People from countries where HIV is endemic ☐ People who use injection drugs ☐ Incarcerated people ☐ Sex workers and their clients ☐ Women ☐ HIV-negative partners of people with HIV ☐ Others
If others, please specify:	_____
Most frequently used mobile device	☐ Android ☐ Apple ☐ Other
If other, please specify:	_____

In general, how many years have you been using Facebook Messenger regularly?

_____ (Years)

To what extent do you use applications related to health/work on your mobile device(s)?

- ◯ Never
- ◯ Very little
- ◯ Sometimes
- ◯ Frequently
- ◯ Very frequently

We would like to ask you a few questions about your general knowledge of HIV.

How do you evaluate your preparedness to advise patients on each of the following areas of HIV care?

	Very Unprepared	Unprepared	Somewhat Unprepared	Somewhat Prepared	Prepared	Very Prepared
HIV/AIDS prevention	◯	◯	◯	◯	◯	◯
HIV/AIDS transmission	◯	◯	◯	◯	◯	◯
HIV/AIDS symptoms, disease progression	◯	◯	◯	◯	◯	◯
HIV/AIDS treatments	◯	◯	◯	◯	◯	◯
Adverse HIV/AIDS drug effects and interactions	◯	◯	◯	◯	◯	◯

What is the minimum number of different drugs that should be included in an ideal antiretroviral treatment regimen?

- ◯ One
- ◯ Two
- ◯ Three
- ◯ Four
- ◯ Don't Know

If a patient cannot afford to take two tablets of a drug like 'Combivir' a day, it is OK to advise them to

- ☐ Take one pill a day
- ☐ Take half a pill twice a day
- ☐ Take 2 pills a day on alternate days
- ☐ Not take it at all
- ☐ Speak to their doctor right away
- ☐ Don't Know

Antiretroviral drugs can completely cure HIV after

- ◯ One Year
- ◯ Two Years
- ◯ Three
- ◯ Never
- ◯ Don't Know

Which of the following are common side effects of Nevirapine?

- ◯ Diarrhea
- ◯ Skin rash
- ◯ Fever
- ◯ Abnormal liver enzyme profile
- ◯ 1 and 4
- ◯ None of the above
- ◯ Don't know

Which of the following drugs is not recommended in Pregnancy?	◯ Nevirapine ◯ Efavirenz ◯ Zidovudine ◯ Emtricitabine ◯ Nelfinavir ◯ Don't Know

How much do you agree or disagree with each of the following statements?

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
Providing information about HIV/AIDS is part of a pharmacist's professional responsibility	◯	◯	◯	◯	◯	◯
I have time while at work to answer questions about HIV/AIDS	◯	◯	◯	◯	◯	◯
People who are educated about how HIV is transmitted sexually will change their risky behavior	◯	◯	◯	◯	◯	◯
People who are educated about how HIV is transmitted by contaminated needles will change their risky behavior	◯	◯	◯	◯	◯	◯
Some people who have HIV/AIDS deserve to have the disease	◯	◯	◯	◯	◯	◯
Drugs to treat HIV/AIDS are too expensive for the pharmacy to keep in stock	◯	◯	◯	◯	◯	◯
Approved treatments for HIV/AIDS simply delay the inevitable and may not be worthwhile	◯	◯	◯	◯	◯	◯
I would provide information about a patient's HIV status to healthcare providers other than the prescribing physician	◯	◯	◯	◯	◯	◯
I might become infected with HIV from contact with an HIV/AIDS patient when I am working	◯	◯	◯	◯	◯	◯
Many of my patients are at high risk for HIV/AIDS	◯	◯	◯	◯	◯	◯

I might be sued if I unknowingly advise an HIV/AIDS patient with incomplete medication information	○	○	○	○	○	○
I am willing to work with a coworker who has HIV/AIDS	○	○	○	○	○	○
Continuing education on HIV/AIDS should be mandatory	○	○	○	○	○	○

How much are you involved in each of the following practices?

	Not Involved	Little Involvement	Moderately Involved	Very Involved	Very Much Involved
Pharmaceutical care to HIV patients	○	○	○	○	○
Adherence counseling for HIV/AIDS patients	○	○	○	○	○
Referral of patients for post-exposure prophylaxis (PEP)	○	○	○	○	○
Refill of ART	○	○	○	○	○
Stocking of ART	○	○	○	○	○
Social responsibility to HIV patients	○	○	○	○	○
Medication treatment and monitoring of ART	○	○	○	○	○
Provision of PEP test for patient	○	○	○	○	○
Home delivery of ART	○	○	○	○	○

How much do you agree or disagree with each of the following statements?

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I believe I am able to confidently manage the complex issues & experiences faced by patients living with HIV	○	○	○	○	○	○
I feel I am unable to spend sufficient time counselling patients living with HIV	○	○	○	○	○	○
I am satisfied with the amount of care I provide to patients living with HIV	○	○	○	○	○	○
I sometimes feel hesitant to dispense HIV medicines to patients living with HIV	○	○	○	○	○	○

How much do you agree or disagree with having each of the following barriers to providing HIV care?	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
Lack of clinical tools (i.e., HIV test kits)	○	○	○	○	○	○
Lack of collaboration with other healthcare professionals	○	○	○	○	○	○
Lack of information or training on HIV/AIDS services	○	○	○	○	○	○
Lack of staff resources	○	○	○	○	○	○
Absence of financial compensation	○	○	○	○	○	○
Lack of space/inadequate physical design of the pharmacy	○	○	○	○	○	○
Lack of time	○	○	○	○	○	○
Patients are not interested in preventive services	○	○	○	○	○	○

Please indicate to which extent you agree with the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Undecided	Somewhat Agree	Agree	Strongly Agree
MARVIN Pharmacist Chatbot meets my approval	○	○	○	○	○	○	○
MARVIN Pharmacist Chatbot is appealing to me	○	○	○	○	○	○	○
I like MARVIN Pharmacist Chatbot	○	○	○	○	○	○	○
I welcome MARVIN Pharmacist Chatbot	○	○	○	○	○	○	○

Please indicate to which extent you agree with the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Undecided	Somewhat Agree	Agree	Strongly Agree
Using MARVIN Pharmacist Chatbot is compatible with all aspects of my work	○	○	○	○	○	○	○
Using MARVIN Pharmacist Chatbot is completely compatible with my current situation	○	○	○	○	○	○	○
I think that using MARVIN Pharmacist Chatbot fits well with the way I like to work	○	○	○	○	○	○	○

Using MARVIN Pharmacist Chatbot fits into my work style	◯	◯	◯	◯	◯	◯	◯

Please indicate to which extent you agree with the following statements:

	Strongly Disagree	Disagree	Somewhat Disagree	Undecided	Somewhat Agree	Agree	Strongly Agree
It is easy for me to use internet health services	◯	◯	◯	◯	◯	◯	◯
I feel uncomfortable to use internet health services	◯	◯	◯	◯	◯	◯	◯
I am very confident in my abilities to use internet health services	◯	◯	◯	◯	◯	◯	◯
I would be able to use internet health services without much effort	◯	◯	◯	◯	◯	◯	◯

Comments

_____

How would you like to be compensated with 50 CAD for filling out the questionnaire?

◯ No compensation
◯ I would like to donate my compensation
◯ Amazon gift card
◯ Another way of compensation - a research coordinator will contact you by phone or email

If you know other pharmacists who may be interested in participating in the study, could you please add their emails?
(you could also share the QR code or the link of the questionnaire with them)

_____

Would you be interested in participating in a 30-minute interview (via phone or zoom)?

◯ Yes
◯ No

Appendix 2. Questionnaire Guide

This questionnaire contains 5 sections, with item response options included brief open-ended and multiple-choice questions and 5 to 7-point Likert scales.

Table 9. Questionnaire Guide

Section	Subsection	Description	Analysis	Number of items	Scale/score
Pharmacists' sociodemographic and professional characteristics		This section provides essential information about the individuals participating in the study.		18	
Knowledge	Objective knowledge	This subsection consisted of multiple-choice questions, with each question having only one correct answer. It comprised items related to HIV and ART and was adapted from a previously utilized instrument in a study involving pharmacists [484]. Objective knowledge refers to factual and verifiable information that is	Responses were categorized as either "correct" or "incorrect," including the choice "I don't know." This variable was rated on a nominal scale with scores of 1 for "correct" and 0 for "incorrect."	5	Binary: correct (1)/ incorrect(0)

		measured through assessments with definitive correct and incorrect answers.			
	Perceived knowledge (preparedness)	This subsection assesses participants' subjective perception of their own knowledge or readiness in the domain of HIV and ART. This variable was extracted from a questionnaire utilized in another study involving pharmacists [330]. Perceived knowledge or preparedness is an individual's subjective perception or belief about their own knowledge or readiness in a specific domain.	Responses were based on a 6-Likert scale, categorized as "Strongly Unprepared", "Unprepared", "Somewhat Unprepared", "Somewhat Prepared", "Prepared", and "Strongly Prepared". Responses were then collapsed into three categories: "Unprepared," "Moderately Prepared," and "Prepared." The total perceived knowledge score was calculated based on the five items in this subsection.	5	Originally Likert: 1 to 6

Attitudes		This section assesses participants' attitudes toward providing HIV care. The attitudes item included both negative and positive statements, and the classification of questions as negative or positive was based on the meaning of each statement. Attitudes represent individuals' evaluations, beliefs, and feelings toward people, objects, ideas, or events and can influence their behavior. It was adapted from a previously utilized instrument in a study involving pharmacists to assess their attitudes toward providing HIV care [330].	Responses were based on a 6-Likert scale, categorized as "Strongly Disagree", "Disagree", "Somewhat Disagree", "Somewhat Agree", "Agree", and "Strongly Agree". Responses were then collapsed into three categories: "Disagree," "Neutral," and "Agree."	13	Originally Likert: 1 to 6
Practice	Involvement	This subsection evaluates the level of	Responses were based on a 5-Likert	9	Originally

		participation and engagement of participants in HIV care services. It was adapted from a previously utilized instrument in a study involving pharmacists to assess their involvement in HIV care services [463].	scale, categorized as “Not Involved”, “Little Involved”, “Moderately Involved”, “Very Involved”, and “Very Much Involved”. Responses were then collapsed into two categories: "Not involved" and "Involved".		Likert: 1 to 5
	Competence	This subsection assesses participants' knowledge, skills, and expertise in delivering HIV care. Competence refers to the ability to effectively and efficiently perform tasks or solve problems, acquired through education, training, and experience. It was adapted from a previously utilized instrument in a study involving	Responses were based on a 6-Likert scale, categorized as “Strongly Disagree”, “Disagree”, “Somewhat Disagree”, “Somewhat Agree”, “Agree”, and “Strongly Agree”. Responses were collapsed into three categories: "Disagree," "Neutral," and "Agree".	4	Originally Likert: 1 to 6

		pharmacists to evaluate their competence in delivering HIV care [461].			
	Barriers	This subsection examines the obstacles or challenges faced by pharmacists in providing HIV care. Identifying and addressing barriers is crucial for promoting inclusivity and equal opportunities. This subsection was adapted from a previously utilized instrument in a study involving pharmacists to identify and assess the barriers they encounter in HIV care [463].	Responses were based on a 6-Likert scale, categorized as "Strongly Disagree", "Disagree", "Somewhat Disagree", "Somewhat Agree", "Agree", and "Strongly Agree". Responses were then collapsed into two categories: "Insignificant" and "Significant"	8	Originally Likert: 1 to 6
Usability	Acceptability	Usability, as defined by the International Organization for Standardization	Responses were based on a 7-Likert scale, categorized as "Strongly	4	Originally Likert: 1 to 7

	Compatibility	(ISO), refers to the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction. Each subconstruct consisted of four items. These subconstructs were adapted from previous literature [485, 486, 487] to assess the usability of the concept of using MARVIN-Pharma by pharmacists in the context of HIV care.	Disagree", "Disagree", "Somewhat Disagree", "Undecided", "Somewhat Agree", "Agree", and "Strongly Agree". Responses were then collapsed into three categories: "Disagree," "Undecided," and "Agree".	4	Originally Likert: 1 to 7
	Self-efficacy			4	Originally Likert: 1 to 7

Appendix 3. Objective Knowledge Questions and Answers

Table 10. Questions and Answers of the Objective Knowledge

Questions	Answers
Q1. What is the minimum number of different drugs that should be included in an ideal antiretroviral treatment regimen?	Three
Q2. If a patient cannot afford to take two tablets of a drug like 'Combivir' a day, it is OK to advise them to….	Speak to their doctor right away
Q3. Antiretroviral drugs can completely cure HIV	Never

Q4. Which of the following is/are the most common side effect(s) of Nevirapine?	Skin rash
Q5. Which of the following drugs is not recommended in Pregnancy?	Efavirenz

Appendix 4. Recommendations for MARVIN-Pharma

The findings from both manuscripts, the rapid review on roles, users, and benefits of chatbots in healthcare, and the preliminary report on informing the adaptation of MARVIN chatbot to pharmacist needs in HIV care provide valuable insights for the configuration and development of MARVIN-Pharma. Based on these findings, recommendations and implications are drawn and presented in Table 11.

Table 11. Recommendations for MARVIN-Pharma Chatbot Content, based on the Pharmacists' Needs Assessment

Pharmacist Needs Assessment	**Content Recommendations for MARVIN-Pharma** MARVIN-Pharma should:	**Recommendations and Implications for MARVIN-Pharma, based on Pharmacist Needs and Chatbot Roles**	
Knowledge gaps in HIV care	Prioritize addressing knowledge gaps, such as HIV treatment, symptoms, and ART side effects.	Provide remote consultations and treatment advice for HIV care	MARVIN-Pharma can offer pharmacists the ability to conduct remote consultations with PWH, enabling them to provide guidance on ART, medication adherence, potential drug interactions, and management of common side effects.
	Develop educational material on specific	Offer mental health support and education	MARVIN-Pharma can provide pharmacists with

	topics like ART medications during pregnancy and ideal treatment regimens.	for patients and healthcare providers	resources and information on mental health support for PWH, including guidance on counseling techniques, referrals to mental health professionals, and educational materials on coping with the psychological aspects of living with HIV.
Information needs of PWH	Incorporate patient information needs, covering areas like diagnosis, prognosis, medication, and social aspects.	Dispense educational material on HIV and ART	MARVIN-Pharma can offer a comprehensive library of educational resources for pharmacists to share with PWH. This content may include information on HIV transmission and prevention, the importance of adherence to ART, self-care strategies, and updates on the latest research and treatment guidelines.
Pharmacists' attitudes towards HIV care	Provide continuous education and training to enhance pharmacists' confidence and clinical knowledge in HIV care.	Address stigma associated with seeking HIV care and being part of an ethnic minority	MARVIN-Pharma can provide pharmacists with guidance on culturally sensitive communication techniques to create a welcoming and non-judgmental environment for PWH. This may involve

			training modules, tips on fostering trust, and addressing specific concerns related to stigma within the local community.
	Offer resources and information on reducing stigmatizing attitudes towards PWH and encourage collaboration among healthcare providers.	Assist in self-management of HIV and ART-related self-care	MARVIN-Pharma can offer tools and reminders to help pharmacists guide PWH in self-management tasks, such as medication adherence tracking, scheduling laboratory tests, and monitoring key health indicators. The chatbot can also provide personalized recommendations based on the patient's specific needs and treatment plan.
Provision of HIV care services	Provide reminders, checklists, and guidelines to assist pharmacists in various HIV care services, such as adherence counseling and PEP referrals.	Provide triaging and risk assessment for HIV-related concerns	MARVIN-Pharma can assist pharmacists in conducting initial assessments and risk screenings for PWH. The chatbot can help identify potential complications or urgent issues that require immediate attention, ensuring timely referrals to healthcare providers or

			recommending appropriate interventions.
Barriers to integrating HIV services	Address barriers like lack of time, clinical tools, staff resources, and information by providing timely information and reminders.	Assist in administrative tasks, data collection, and research-related work	MARVIN-Pharma can offer features that streamline administrative tasks for pharmacists, such as data collection for patient monitoring, medication inventory management, and facilitating research activities. This would help pharmacists optimize their workflow and allocate more time to direct patient care.
	Improve collaboration and communication between healthcare providers to facilitate comprehensive HIV care services.	Empower pharmacists to provide patient-centered care and education	MARVIN-Pharma can equip pharmacists with tools to personalize care and education based on the individual needs and preferences of PWH. This could include tailoring information on medication regimens, lifestyle modifications, and preventive measures to align with the patient's specific circumstances and goals.
		Enhance efficiency in retrieving and	MARVIN-Pharma can serve as a knowledge base for

		organizing HIV- and ART-related information	pharmacists, providing quick and reliable access to up-to-date information on HIV medications, drug interactions, treatment guidelines, and emerging research. The chatbot can assist in organizing this information in a user-friendly format for easy retrieval during patient consultations.
Familiarity with digital tools	Leverage pharmacists' familiarity with technology by designing user-friendly interfaces and features.	Contribute to better adherence to ART, improved patient outcomes, and reduced healthcare costs	MARVIN-Pharma can support pharmacists in reinforcing medication adherence strategies, monitoring patient progress, and facilitating regular follow-ups. By helping PWH achieve better adherence to ART, the chatbot can contribute to improved health outcomes, reduced viral load, and potentially lower healthcare costs associated with hospitalizations and complications.
	Provide ongoing support and training to		

	ensure pharmacists are comfortable using MARVIN-Pharma and other digital tools.		
	Enhance the usability for pharmacists by: Gathering user feedback to improve usability, accessibility, and effectiveness.		
Provide reliable and instant information retrieval for pharmacists	Develop it as a reliable tool for ART- and HIV-related information retrieval by connecting it with a constantly updated reliable evidence-based source.		